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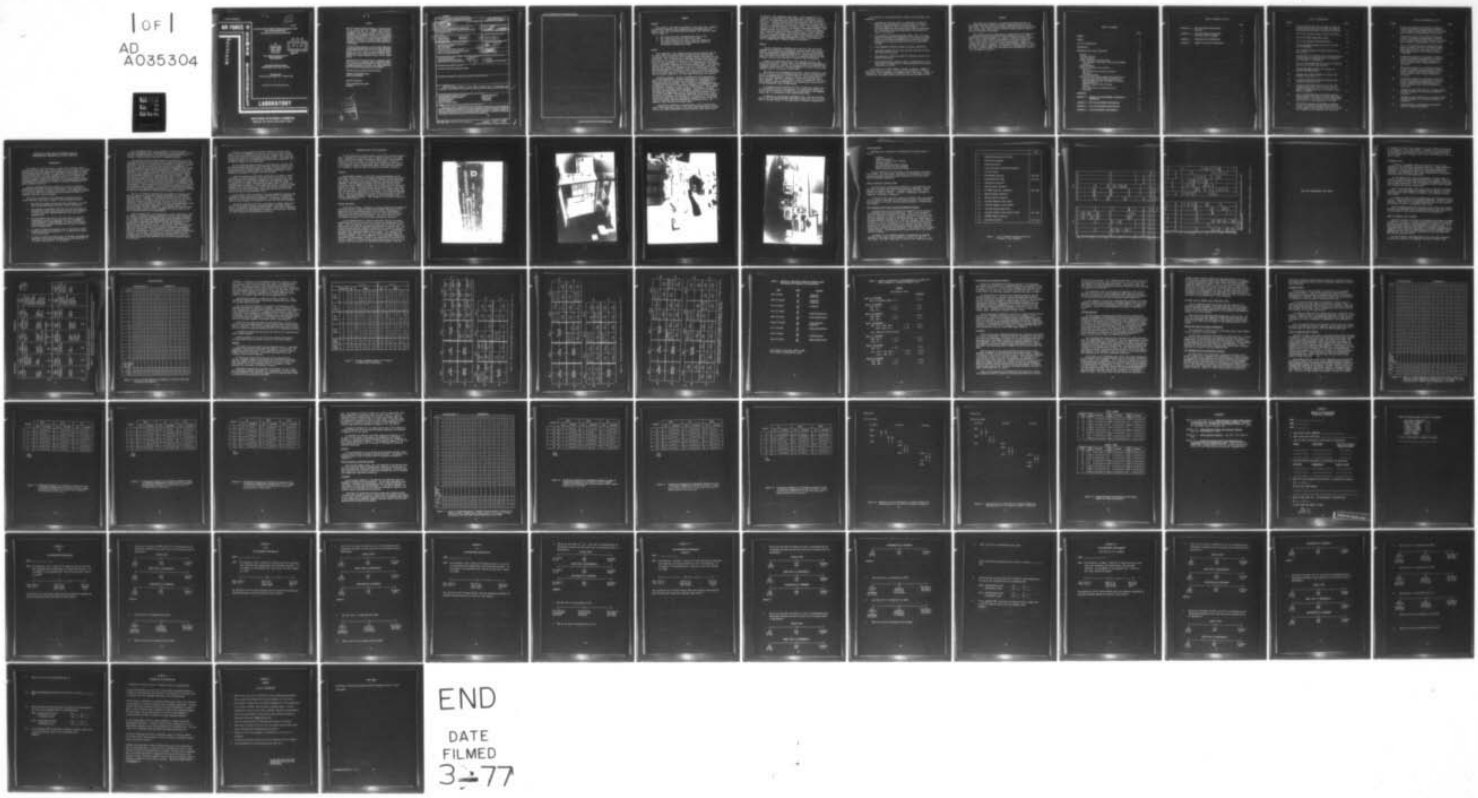

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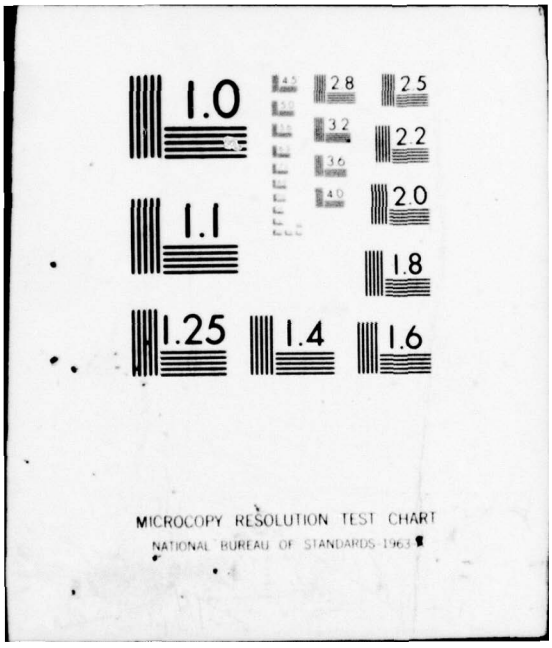
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AIR FORCE HUMAN RESOURCES LABORATORY

EVALUATION OF THREE TYPES OF TECHNICAL DATA FOR TROUBLESHOOTING:

METHODOLOGY FOR FIELD EVALUATION

By

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AIR FORCE SYSTEMS COMMAND
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This technical report has been reviewed and is approved.

GORDON A. ECKSTRAND, Director
Advanced Systems Division

Approved for publication.

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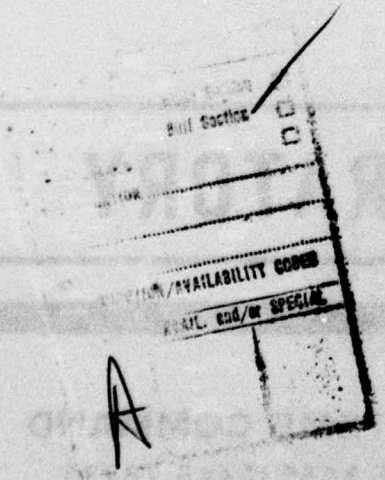
Commander



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides a detailed description of the experimental methods used in a study to evaluate the effectiveness of three types of technical data for troubleshooting, fully proceduralized troubleshooting aids (FPTA), logic tree troubleshooting aids (LTTA), and technical orders (TO). The purpose of the study was to evaluate the effectiveness of these technical data by determining which provided the best support for technicians troubleshooting two moderately complex electronic systems, the AN/APN-147 and AN/ASN-35.

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SUMMARY

PURPOSE

The purpose of the project described in this report was to conduct an evaluation comparing fully proceduralized troubleshooting aids (FPTAs), logic tree troubleshooting aids (LTTAs), and technical orders (TOs) in terms of:

1. The costs involved in developing each type of aid.
2. The technical accuracy of each type of data.
3. The effectiveness of each type of data for supporting maintenance personnel of varying experience levels in performing troubleshooting tasks.

METHOD

Cost comparison: The available data on costs to produce each of the three types of technical data were obtained from FPTA and LTTA contractors, and from the Air Force Logistic Centers responsible for TO procurement. Due to differences in coverage, developer experience, data base and types of systems for which the technical data were developed, difficulty was experienced in arriving at a single measure which would permit a meaningful comparison of the three document types. The approach selected was to base the analysis on the cost to produce a page unit. A page unit was defined as a standard 8 1/2- by 11-inch format. Use of this standard made it necessary to convert the 4- by 8-inch page format used in the LTTA checkout procedures for organizational level maintenance into the standard page unit. No other page conversions were required.

Technical accuracy: Review of worldwide Air Force maintenance actions was undertaken to provide identification of maintenance areas which could serve as representative candidates for development of troubleshooting test problems. Thirty specific troubleshooting test problems were selected and distributed throughout the AN/APN-147 (radar) and AN/ASN-35 (computer) systems of the C-141A aircraft. Each problem was inserted into working system equipment. The effects on system operation were identified and a systematic evaluation of the accuracy of the technical documentation types in supporting the isolation of the faults was undertaken. Records were maintained on the errors found in the data and on whether the procedure led to isolation of the problem. Those faults which could be successfully isolated by each of the three types of technical data were retained for consideration as a test problem in the field data collection phase.

Experimental evaluation of effectiveness of each technical data type: Three experience levels of Air Force technicians in the Avionics Inertial and Radar Navigational Systems Specialty (AFSC 328X4) served

as subjects. The experience levels were: recent graduates of the technical training course (no field experience); technicians with six months or less experience; and technicians with more than six months experience. Eighteen technicians at each experience level were used as subjects. A determination was made that it would not be appropriate to test the no-experience group on technical orders. This decision made it necessary to use two different, but similar, experimental designs. Both designs involved repeated measures on subjects. In the first design, the no-experience group was tested using two types of data, FPTAs and LTTAs. In the second design, the two experienced groups of subjects were tested using all three types of data. Data collection was accomplished at Keesler Technical Training Center and at three Military Airlift Command bases: McChord, Travis, and McGuire.

RESULTS

The cost comparison, primarily due to the fact that sufficient comparable data could not be assembled, produced inconclusive results. However, the available data did suggest that the costs of developing fully proceduralized troubleshooting aids in a newly developed system where all support data would also have to be generated may not be much different from the costs incurred in technical order development.

Errors in accuracy were found in both the FPTA and LTTA. The errors discovered vary in their impact on performance from negligible to completely disruptive. However, no accuracy errors were found that were considered beyond solution. Increased emphasis on quality control would eliminate most of the accuracy errors found.

The results of the experimental evaluation clearly demonstrate that the use of proceduralized troubleshooting aids resulted in significantly better troubleshooting than the use of the TO. This finding held for two of the three measures: proportion of problems solved and spare parts consumed. For the third measure, time to troubleshoot, the use of TOs resulted in better performance at the organizational level but not at the intermediate level of maintenance.

In comparing the FPTA against the LTTA, the FPTA was superior for the no-experience group on all measures. For experienced technicians, use of the FPTA resulted in slightly better performance on all measures except time to troubleshoot at the organizational level.

In addition to the objective performance data, subjective opinion data of the technicians provided unqualified support for the use of the FPTA as the most favored of the three types of technical documentation.

The findings of this research effort support the following recommendations:

1. Consideration should be given to development of FPTAs or LTTAs for new procurements of technical data for troubleshooting (whether for new or existing systems). It is especially important that these types of data be considered for intermediate level maintenance where the benefits are likely to be greatest.

2. Proceduralized troubleshooting data (FPTA, LTTA, or hybrid) should be developed for a modern Air Force system for operational use to provide an opportunity to study the problems associated with using this type of data in an operational setting.

3. Strong emphasis should be placed on accuracy evaluation.

4. Additional analyses of the costs and cost benefits of FPTAs and LTTAs should be made.

5. The potential of FPTAs and LTTAs for reducing training costs should be evaluated.

6. Strong consideration should be given to modification of the LTTA format to include more of the proceduralization material contained in the FPTA.

This report is in three volumes: Volume I presents a summary of the project and the results. The present volume presents a detailed description of the experimental procedures used in the study. Volume III presents the test administrator's guide and the job performance tests.

PREFACE

This study was initiated by the Advanced Systems Division, Air Force Human Resources Laboratory (AFHRL), Wright-Patterson Air Force Base, Ohio. The research was performed by Systems Research Laboratories, Inc., Dayton, Ohio, under Contract F33615-75-C-5103, with Dr. Norman R. Potter as principal investigator.

The authors wish to acknowledge the contributions of the members of the Systems Research Laboratories field evaluation team, Mr. Ned H. Kearns, Mr. P. Richard Hubbert, Mr. James V. Landolfi, and Mr. Daniel L. Rice. Without their efforts and dedication to the data collection effort, this project could not have been accomplished. Further, an appreciation must be expressed to MSgt Bobby Spaulding, AFHRL, for his guidance and support throughout the field data collection effort, and to Mr. John J. Klesch, AFHRL, for his guidance and knowledgeable consultation throughout the project.

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EVALUATION OF THREE TYPES OF TECHNICAL DATA FOR TROUBLESHOOTING: METHODOLOGY FOR FIELD EVALUATION

INTRODUCTION

The purpose of this effort was to collect data on which to base objective decisions about the relative merits of two new types of technical documentation, fully proceduralized troubleshooting aid (FPTA) and logic tree troubleshooting aid (LTTA), in comparison to the standard Air Force technical order (TO). The major emphasis of this effort entailed the collection of data through the design and conduct of a carefully controlled systematic experimental evaluation of troubleshooting performance incorporating the use of the three types of technical documentation to guide technical activities.

Distinct advantages have been claimed for the use of technical documentation other than Air Force TOs; however, little empirical data can be found to support, or refute, these claims. This study was designed to supply objective data on which the merits of FPTAs and LTTAs, in comparison with TOs, could be weighed.

The specific objectives of the experimental evaluation were to obtain data which could permit answers to the following questions:

1. Does FPTA performance differ from LTTA performance? Are both FPTA and LTTA performance different from TO performance?

2. Does quality of performance with each of the three types of documentation depend upon experience level of the technician? Is there interaction between experience level and type of documentation?

3. Does performance with each of the three types of technical documentation differ for organizational and intermediate level maintenance troubleshooting? Is there an interaction between type of technical documentation and level of maintenance troubleshooting?

4. Is there an interaction between level of maintenance troubleshooting and level of experience? If so, what is the nature of the interaction?

5. Is there an interaction among types of technical documentation, experience level and level of maintenance troubleshooting? If so, what is the nature of the interaction?

As a preliminary step in the evaluation of the three types of technical documentation for troubleshooting Air Force equipment, each of the data types was subjected to an empirical demonstration of its accuracy in permitting the isolation of equipment problems.

The equipment problems against which the documentation types were evaluated were selected after an intensive review of worldwide Air Force maintenance actions on the AN/APN-147 and AN/ASN-35 systems for calendar year 1974. The data contained in these reports were summarized to provide identification of maintenance areas which appeared to be logical and representative candidates for development of troubleshooting test problems. In an attempt to provide field verification of the correctness of the data summarizations, the results were discussed in detail with maintenance personnel at Charleston AFB, South Carolina. (This base was not included in the field evaluation effort.) As a result of the Charleston AFB interviews, detailed information, not available from the AFLC reports, was obtained on the specific parts or components which were contributing most to the maintenance problems of the AN/APN-147 and the AN/ASN-35. This information was considered in selecting the specific troubleshooting test problems. A total of 30 malfunctions was selected and located on an applicable system schematic to verify that the problems selected were satisfactorily distributed throughout the system.

Each of the candidate problems was investigated in working equipment to catalog the operational symptoms associated with the failed equipment part or component. Once the known effects of the fault had been identified, a systematic evaluation of the accuracy of each of the technical documents in supporting the isolation of the faults was undertaken. This evaluation was based on actual troubleshooting performance on powered equipment using each of the document types as the guiding document for fault isolation. The approach just described made use of the same (primary and test) equipment and aids as used in the field evaluation portion of the experiment.

Certain problems had to be substituted to assure compatibility with the degree of simulation fidelity employed in the Air Force simulations of a C-141A cockpit and intermediate (shop) level maintenance benches. As an example, the technical documentation guiding isolation of certain of the faults originally selected directed the troubleshooter to the Horizontal Situation Indicator (HSI). The HSI was represented by a nonfunctioning simulation in the Air Force trailer; thus, the particular fault could not be resolved by the technical documentation/equipment simulation combination. In an instance such as this, a new candidate fault was selected and the ability of the types of technical documentation to find it was verified. Any editorial or content problem with the candidate types of technical documentation discovered as a result of following this process was reported to the Air Force technical monitor for correction.

Eighteen airmen graduates of Keesler Technical Training Center (KTTC) Course No. 3ABR32834 served as one of the three subject groups. Subjects were first-enlistment airmen who had completed basic training and who went directly into technical training at KTTC. The airmen were retained at Keesler for a two-week period beyond course graduation and entered as subjects in this experiment.

The two remaining subject groups in the design were obtained from Air Force enlisted personnel in the 328X4 AFSC, Avionics Inertial and Radar Navigational Systems Specialist, assigned to operational units of the Military Airlift Command (MAC) and performing maintenance on the AN/ASN-35 and AN/APN-147 systems in C-141A aircraft.

These two groups were classified on the basis of length of experience with the C-141A equipment. Each group had a size of n=18. One group consisted of airmen with six months or less equipment experience on the system; the second group, airmen with more than six months experience on the system. Three MAC bases were visited to obtain the required number of subjects. Each airman selected as a subject was made available for a two-week period. During this period, the airmen continued to work their normal shifts and served as subjects for a four-hour period out of each eight-hour shift.

An Air Force trailer configured to include AN/ASN-35 (computer) and AN/APN-147 (radar) bench mock-ups and a mock-up of the C-141A cockpit comprised the main experimental apparatus. In addition, a number of items of test equipment were available for use with the prime equipment.

Equipment components had faults introduced in a manner which would produce 15 equipment problems with known symptoms and known overall effects on equipment operating characteristics. These failed components were provided for the experimenters to insert in the equipment following the order required by the experimental procedure.

METHODOLOGY FOR FIELD EVALUATION

In the field data collection phase of the effort, selected subjects were: evaluated for proficiency with 13 separate items of test equipment; provided with remedial training on those items of test equipment where proficiency was below the criterion established; trained to criterion in the use of FPTA and LTTA; and evaluated for their ability to successfully isolate predetermined faults, which had been inserted into equipment, using the types of technical data under evaluation.

SUBJECTS

An evaluation sample of 54 Air Force enlisted personnel in the 328X4 AFSC (Avionics Inertial and Radar Navigational Systems Specialist) was studied. Of this total of 54 subjects, 18 were 3-level airmen who were recent graduates of the Keesler Technical Training Center Course 3ABR32834. The remaining 36 subjects were obtained from Air Force operational units. Eighteen of these 36 were airmen who had either been awarded the 5-level of the AFSC within the last six months or for whom award was imminent. The remaining 18 subjects were 5-level airmen with more than six months experience on the system. A determination was made that it would not be appropriate to test the Keesler group on technical orders. This decision made it necessary to use two different, but similar, experimental designs. These designs are described in detail in the following sections.

TESTING LOCATIONS

An Air Force trailer, configured to include AN/ASN-35 and AN/APN-147 bench mock-ups and a mock-up of the C-141A cockpit, was taken to four separate Air Force locations (Keesler Air Force Base, Mississippi; McChord Air Force Base, Washington; Travis Air Force Base, California; and McGuire Air Force Base, New Jersey). The trailer served as the experimental setting for the controlled experimental evaluation.

It was recognized that it would be extremely difficult to obtain adequate access to C-141 aircraft for use with the organizational level tests. Thus, the mock-up of the C-141 cockpit and the avionics equipment bays of the C-141 was developed and installed in the test van. The cockpit mock-up provided a means of simulating the flightline troubleshooting tasks without requiring access to an aircraft. It consisted of mock-ups of all instrument panels in the cockpit. All AN/APN-147 and AN/ASN-35 components were "live" and functioned in the same manner as the actual cockpit. All other components on the instrument panels were represented by photographs. Figure 1 is a photograph of the exterior of the van. Figure 2 is a view of the cockpit mock-up area inside the van. Figures 3 and 4 are views of the bench mock-ups contained in the van.

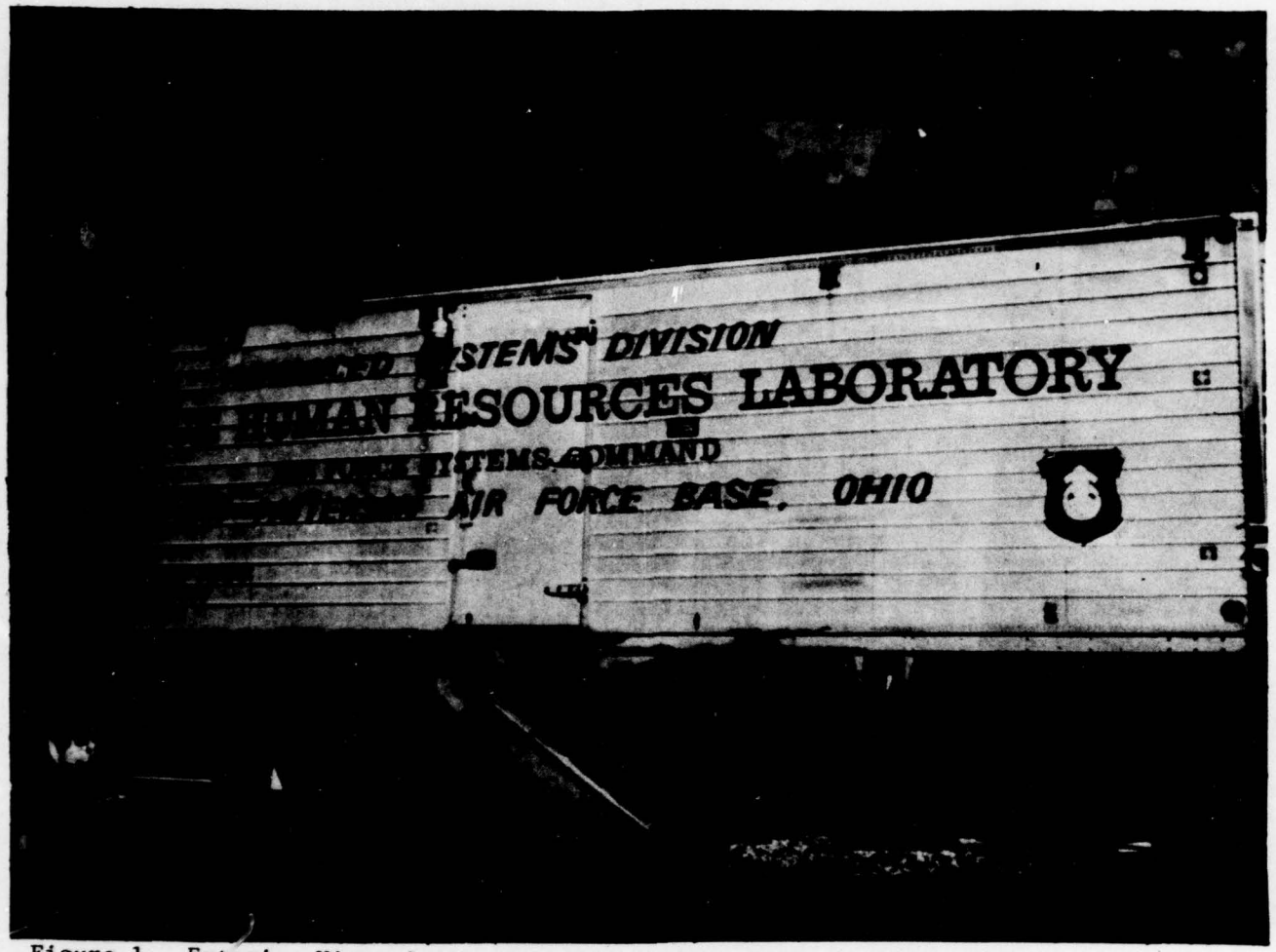


Figure 1. Exterior View of Air Force Van Used to House the C-141A Cockpit Mockup and the Radar and Computer Maintenance Benches Used in Field Data Collection

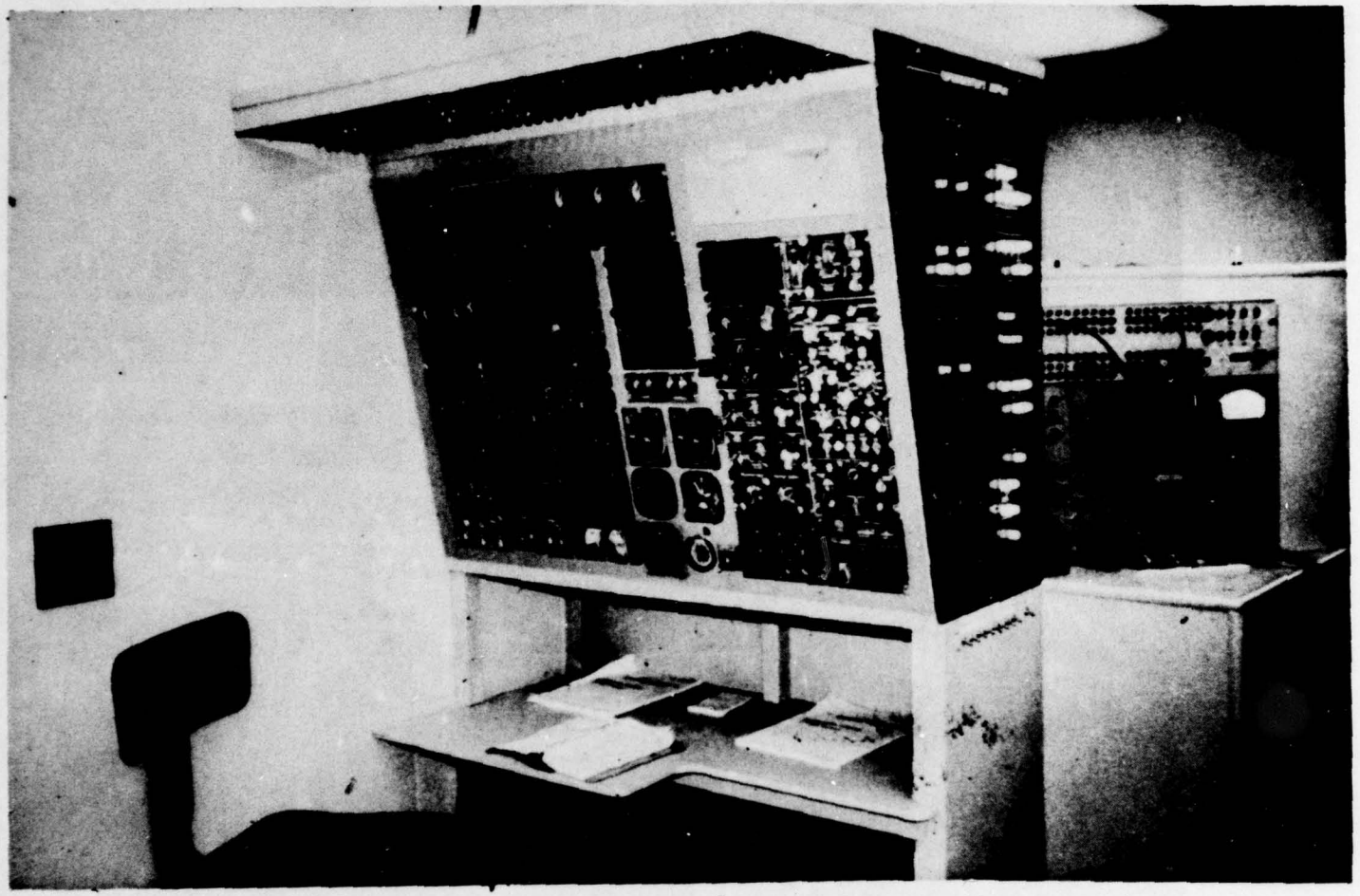


Figure 2. View of the Navigator Panel of the C-141A Mockup

Figure 3. View of the Radar Maintenance Bench

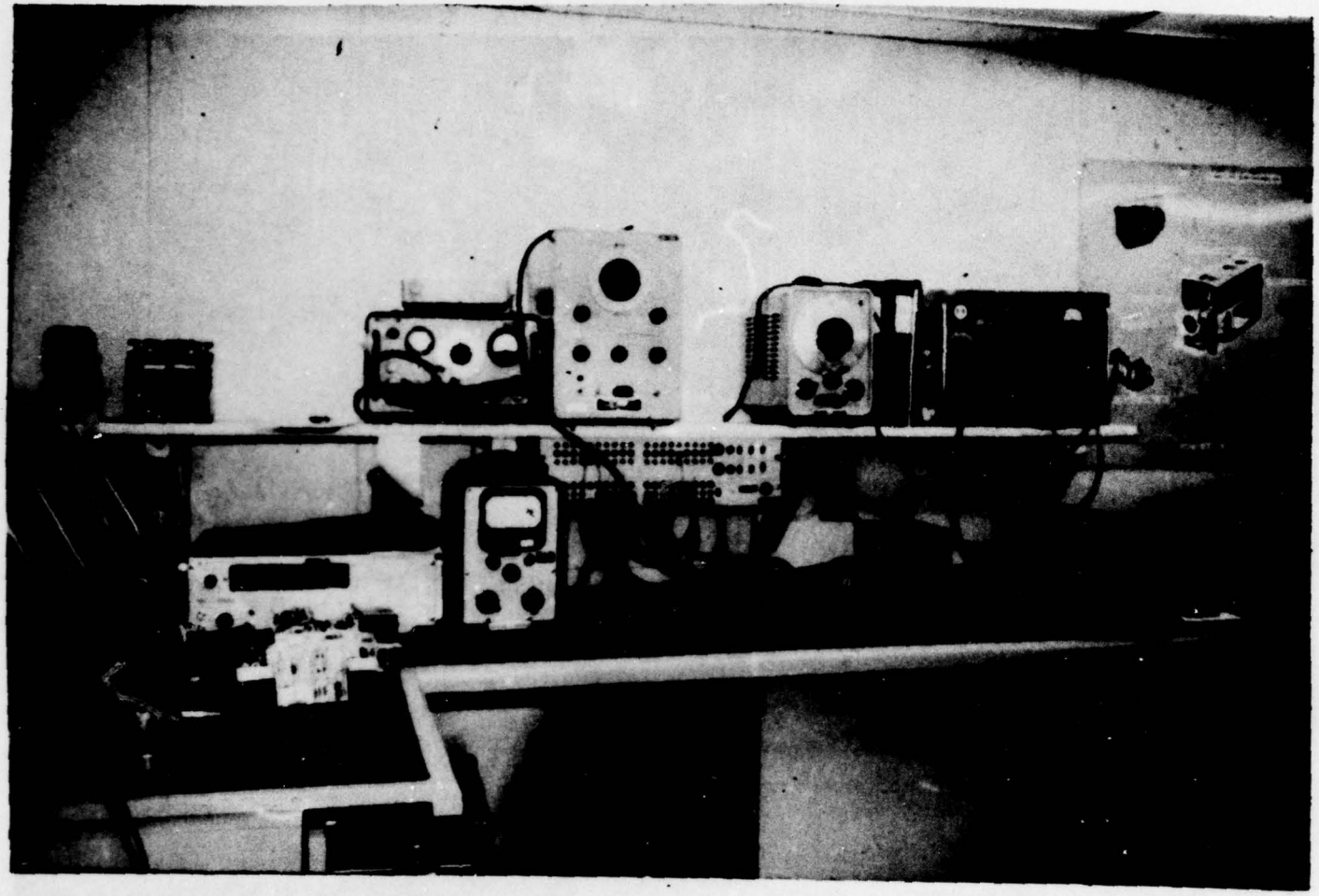


Figure 4. View of the Computer Maintenance Bench

ITEMS CONSIDERED

Procedures were considered for handling the following items of concern:

- Subjects
- Graduating classes
- Order of technical data training
- Equipment faults
- Test equipment proficiency testing
- Remedial training on test equipment
- Data collection on ancillary factors

Subject availability was different at the operational locations than at KTTC. For this reason, the manner of consideration of each of the above variables has been outlined separately for the two experimental situations encountered.

KEESLER TECHNICAL TRAINING CENTER

At this location, airmen were available on a full-time basis for two weeks following their graduation from Course 3ABR32834. Classes graduate at biweekly intervals. Graduation dates and sizes of the classes used were as follows: 7 October, 7 graduates; 21 October, 9 graduates; 4 November, 9 graduates.

At Keesler, each class was treated as a separate unit, and entered into the study as described in the following sections. Each graduate was assigned to an initial evaluation group by means of a random selection process.

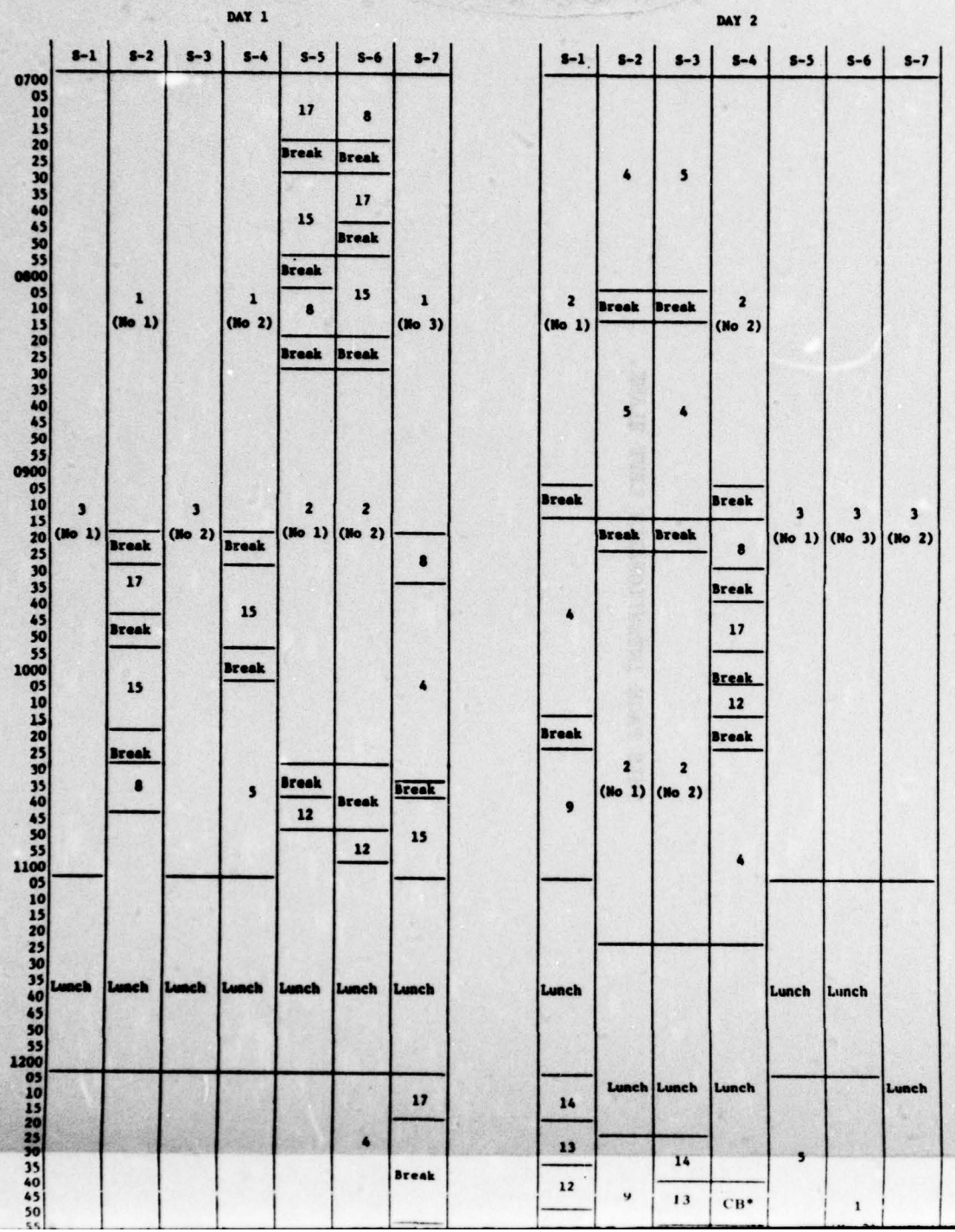
Test Equipment Proficiency Testing and Remedial Training

Thirteen items of test equipment were required in this evaluation for performing troubleshooting procedures. Each of the performance tests was available to evaluate the level of proficiency of each technician in using the 13 items of equipment (Figure 5). Discussion with Air Force personnel resulted in the consensus that the recent Keesler graduates would not be proficient in the test equipment items called out in Figure 1. Due to the short period of time the evaluation team had access to each class of graduates, it was decided that more effective utilization of time would be accomplished through bypassing the proficiency tests and subjecting each graduate to the complete set of remedial training courses. This procedure was followed with each of the three classes at Keesler.

An example of the schedule followed in conducting the remedial training on the items of test equipment is depicted in Figure 6. In this figure, the number appearing in a block in any column can be used

		USE
1	410B VTVM Vacuum Tube Voltmeter	
2	260 VOM Volt Ohmmeter	
3	545B Oscilloscope	
4	5245L Electronic Counter and Plug-ins	
5	TV2 Tube Tester	
6	TS-148 Radar Test Set	Not Used
7	803 Differential VTVM	Not Used
8	200CD Audio Oscillator	
9	URM-25D Signal Generator	
10	TS-1100/U Test Set, Transistor	Not Used
11	CMA-544 Doppler Simulator	
12	CMA-546 Doppler Generator	
13	3322-900 Computer Cards Tester	
14	3322-902 Computer Drives Tester	
15	3322-905 Navigational Tester	
16	3322-901 Computer Relay Chassis Tester	Not Used
17	SG299B/U Signal Generator	
18	Kay Sweep Generator	Not Used

Figure 5. List of Remedial Training Courses for 18 Items of Test Equipment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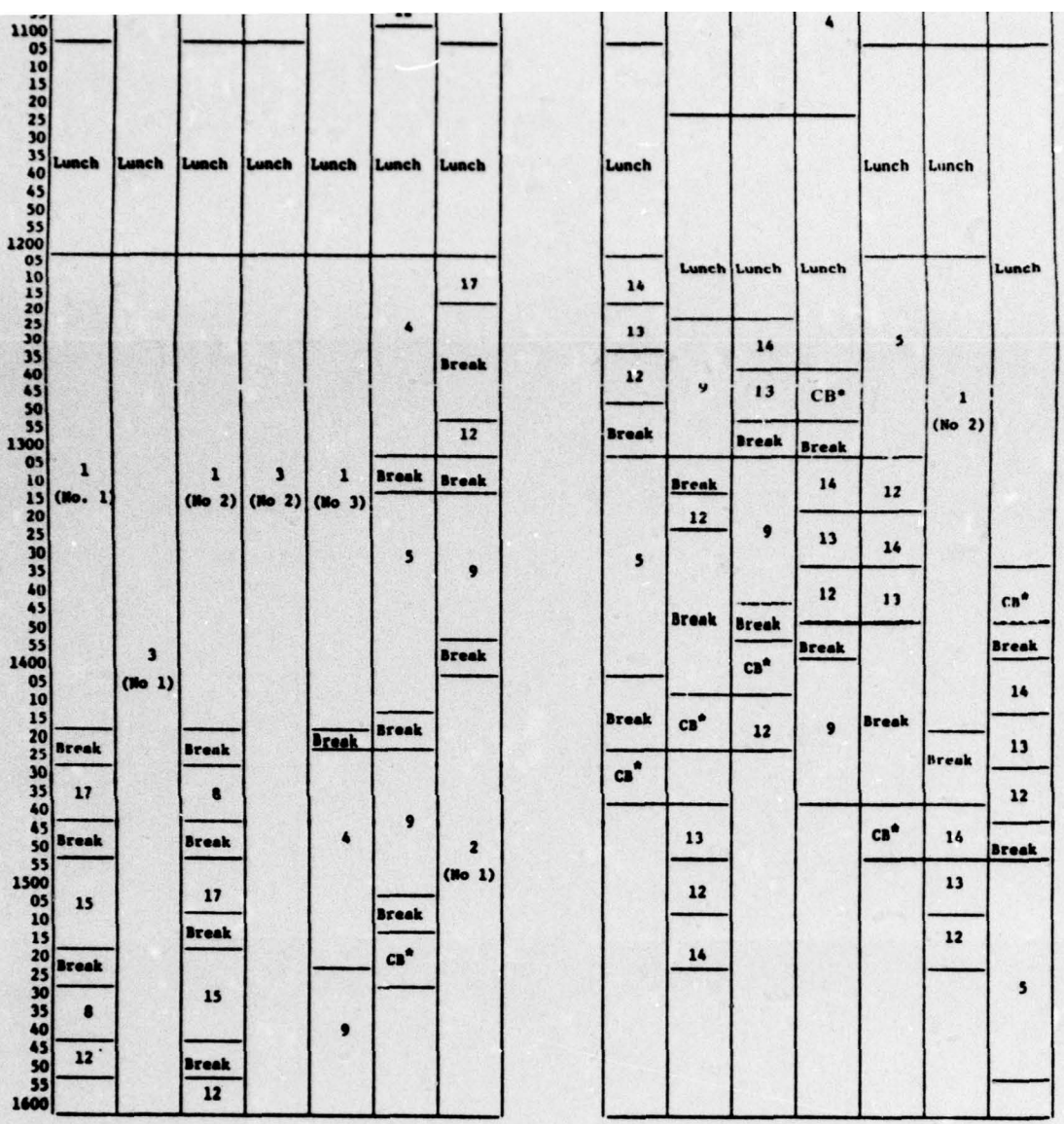

*Circuit Breaker

(Refer to Figure 1 for identification of test equipment training course corresponding to numbers appearing in columns above.)

Figure 6. Test Equipment Remedial Training Schedule for a Class Size n = 7

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to identify the item of test equipment for which remedial training was to be conducted in that time period. In addition, a training program was included in this schedule to familiarize the graduates with the circuit breaker panel included as part of the C-141A mock-up in the Air Force trailer.

EQUIPMENT FAULTS

A total of 15 equipment faults were selected for use as test problems in the experimental evaluation (Figure 7). These faults were organized so that four were representative of organizational level maintenance troubleshooting tasks on the AN/ASN-35 and AN/APN-147 equipment. The remaining 11 faults were representative of intermediate level maintenance troubleshooting tasks.

At the organizational level of maintenance, an equal number of computer (ASN-35) and radar (APN-147) faults were included. Thus, the four organizational level faults consisted of two computer malfunctions and two radar malfunctions. The 11 intermediate level faults included five computer and six radar malfunctions.

One of the intermediate level faults was not used with the Keesler graduates. This fault (Number 9 in Figure 7) was excluded to balance the intermediate level problems at Keesler to five computer and five radar faults.

An attempt was made with the organizational and intermediate level faults to categorize them on an additional dimension: levels of troubleshooting. Three levels of troubleshooting were used for this purpose--troubleshoot to unit, to subassembly, and to part.

Both the organizational and intermediate level faults were counterbalanced in presentation order to subjects, and each fault was isolated an equal number of times with LTTA and with FPTA documentation.

ORDER OF TECHNICAL DATA TRAINING

Reference is made to the order of counterbalancing scheme diagrammed in Figure 8. The type of technical data training received first by the subjects was determined by random assignment of a subject to one of the 18 counterbalanced orders of technical data for problem solving. In developing these counterbalancing orders, a systematic counterbalancing scheme was used for both the organizational and the intermediate level problems with the check that each problem was tested nine times with FPTA and nine times with LTTA.

As can be seen by consulting Figure 8, the first seven sequences started with an FPTA in four instances, and with an LTTA in three

	ORGANIZATION		INTERMEDIATE					
	1 Radar Unit	2 Computer Unit	5 Radar Subassembly	6 Computer Unit	7 Radar Subassembly	8 Computer Part	9* Radar Part	LEGEND L ≡ LTTA F ≡ FPTA T ≡ TO
	Antenna	Auxiliary Cross Track Control-Indicator	Frequency Tracker	Computer Card	Receiver/ Transmitter	Computer Card	(Frequency Tracker) Electronic Control Amplifier Subassembly	
	Drift Motor (B7603)	Relay (K4402)	Crystal (Y6701) Frequency Mixer	Transistor (Q2105) Triple Binary Card	Filter (FL8101) Modulator	Diode (CR1203) NPN Multiar	Tube (V7901) Electronic Control Amplifier	
				TIME REQUIRED (IN MINUTES)				
L	10	32	60	30	50	20		
F	30	45	60	10	30	20	60	
T								
	3 Radar Unit	4 Computer Unit	10 Radar Part	11 Computer Subassembly	12 Radar Part	13 Computer Part	14 Radar Part	15 Computer Part
	Receiver/ Transmitter	Computer	Receiver/ Transmitter	Computer	Antenna	Control-Indicator	(Frequency Tracker) Frequency Mixer Subassembly	Auxiliary Cross Track Control Indicator
	Klystron (V6201)	Transistor (Q1603)	Tube (V6403)	Resistor (R301) Track Resolver Drive Assembly	RF Diode CR7601 CR7602 Side "A"	Switch SW5405	Crystal (Y6701) Frequency Mixer	Relay (K4402)
L	25	13	90		30			
F	35	17	60		50			
T								

*Problem 9 not used with Kessler AFB subjects.

Figure 7. Identification of Problems used in Field Evaluation of Three Types of Technical Data, with Expected Time Required to Troubleshoot

KEESLER SUBJECTS

	ORGANIZATIONAL				INTERMEDIATE									
Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	F	F	L	L	L	F	L	F	L	F	L	F	L	F
2	F	L	L	F	F	L	F	L	F	L	F	L	F	L
3	L	L	F	F	L	F	L	F	L	F	L	F	L	F
4	L	F	F	L	F	L	F	L	F	L	F	L	F	L
5	F	F	L	L	L	F	L	F	L	F	L	F	L	F
6	F	L	L	F	F	L	F	L	F	L	F	L	F	L
7	L	L	F	F	L	F	L	F	L	F	L	F	L	F
8	L	F	F	L	F	L	F	L	F	L	F	L	F	L
9	F	F	L	L	L	F	L	F	L	F	L	F	L	F
10	F	L	L	F	F	L	F	L	F	L	F	L	F	L
11	L	L	F	F	L	F	L	F	L	F	L	F	L	F
12	L	F	F	L	F	L	F	L	F	L	F	L	F	L
13	F	F	L	L	L	F	L	F	L	F	L	F	L	F
14	F	L	L	F	F	L	F	L	F	L	F	L	F	L
15	L	L	F	F	L	F	L	F	L	F	L	F	L	F
16	L	F	F	L	F	L	F	L	F	L	F	L	F	L
17	F	F	L	L	L	F	L	F	L	F	L	F	L	F
18	L	L	F	F	F	L	F	L	F	L	F	L	F	L
No. Times Data Named is Used														
LTTA	9	9	9	9	9	9	9	9	9	9	9	9	9	9
FPTA	9	9	9	9	9	9	9	9	9	9	9	9	9	9

Figure 8. Order of Counterbalancing of Problems to Technical Data Type for Keesler AFB Subjects

instances. In Figure 9, the 18 sequences have been reordered to group into type of technical documentation first used. The sequences were also partialed into class size groups matching those encountered at Keesler. As mentioned earlier, the first Keesler class had 7 graduates, the second class had 9, and the third 9 also. For the third class, only the two sequences required to complete the planned sample size are depicted. The 7 graduates remaining in the third class were given a repeat of the sequence used for the first graduating class.

The pairing of subject to sequence is shown in Figure 9. This pairing was accomplished within each Keesler graduating class by means of a random selection process.

For the first two subjects, the sequence of intermediate level problems evaluated was arbitrarily assigned. These two sequences were than systematically counterbalanced until the presentations were exhausted. A new sequence was generated by a random selection process, using the restriction that no sequential arrangement of two or more problems could be repeated. This new sequence was systematically counterbalanced until its presentations were exhausted. The procedure was then repeated to secure the necessary number of different orders of presentation.

Since both the radar and computer bench mock-ups in the Air Force trailer were used simultaneously, a rigid computer-radar problem pairing had to be observed. The restriction mentioned above had to be violated twice to secure the required problem pairing on the intermediate problems.

A separate counterbalancing process was used for the organizational level problem sequence.

Shown in Figures 10, 11, and 12 are the complete training and testing schedules used at Keesler with each of the three classes.

Subjects

The subject pool at Keesler has been described earlier. Basically, 25 subjects were available from which the sample of 18 was drawn. All graduating classes were used *in toto*, providing 25 subjects on which complete data were collected. The decision was made to omit the 7 October class from the analysis.

To facilitate subject reporting over the two-week period of testing, a separate schedule was prepared for each subject indicating where the subject would be utilized (and where he was to report) for each one-half day of the evaluation period. An example of these schedules for one airman is presented in Table 1.

Comparable information was provided in schedules for each of the four test administrators (see Table 2). Additionally, in this schedule, an identification of the problem by number and the technical data format to be used with the problem was included.

		F P T A							L T T A						
	SUBJECT	ORG.		INTER.					ORG.		INTER.				
	1	1	2	6	8	10	12	14	4	3	5	13	11	15	7
FPTA	2	1	3	5	7	15	11	13	4	2	6	14	12	10	8
FIRST	3	1	4	8	10	12	14	6	3	2	15	13	11	7	5
	4	2	3	7	13	15	11	5	4	1	14	12	10	8	6
	5	2	4	15	11	13	5	7	3	1	8	14	10	6	12
LTTA	6	3	4	5	11	7	13	15	2	1	12	10	8	6	14
FIRST	7	2	1	10	12	14	6	8	3	4	7	15	11	5	13
	8	3	1	11	13	5	7	15	2	4	14	8	12	6	10
FPTA	9	4	1	12	14	6	8	10	2	3	13	7	11	5	15
FIRST	10	3	2	13	5	7	15	11	1	4	8	12	6	10	14
	11	4	2	14	6	8	10	12	1	3	7	11	5	15	13
	12	4	3	15	7	5	13	11	1	2	12	6	10	14	8
	13	1	2	10	8	6	14	12	4	3	11	5	15	13	7
LTTA	14	1	3	8	6	14	12	10	4	2	5	15	13	7	11
FIRST	15	1	4	7	5	11	13	15	3	2	6	10	14	8	12
	16	2	3	15	5	11	7	13	4	1	14	10	6	12	8
FPTA FIRST	17	2	4	6	12	8	14	10	3	1	13	15	5	11	7
LTTA FIRST	18	3	4	10	6	12	8	14	2	1	7	13	15	5	11

Figure 9. Problem Assignment Sequence for Subjects at Keesler AFB, Mississippi

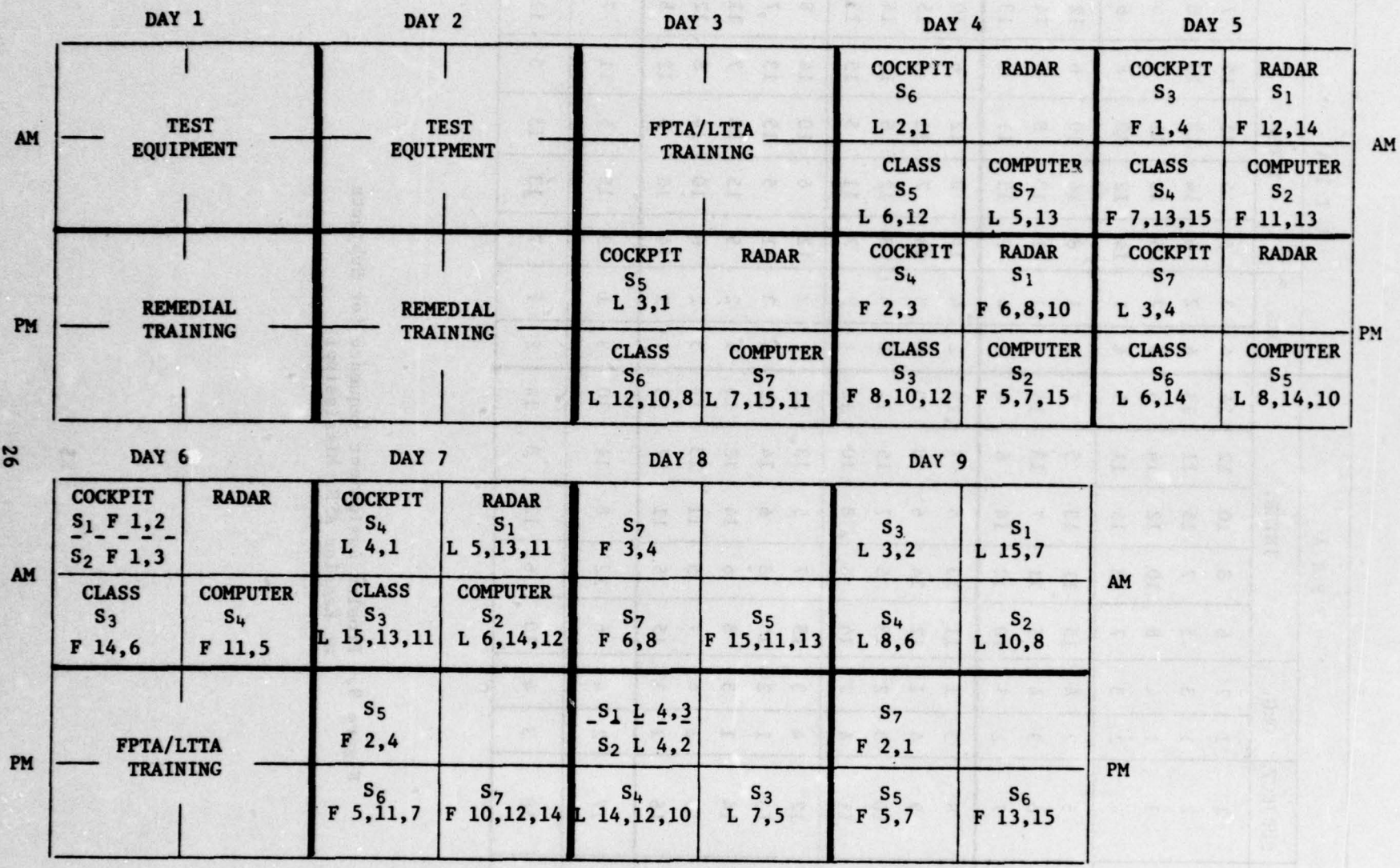


Figure 10. Training and Testing Schedule for Keesler AFB Students, Class Size n = 7

	DAY 1	DAY 2	DAY 3		DAY 4		DAY 5		
AM	TEST EQUIPMENT	TEST EQUIPMENT	FPTA/LTTA TRAINING		S_{14} L 4,2 - - - - - S_{15} L 3,2	S_{12} L 12,6,10	S_8 F 3,1 - - - - - S_9 F 4,1		AM
					S_{16} L 12,8	S_{13} L 11,5,15	S_{11} F 14,6,8	S_{10} F 15,11	
PM	REMEDIAL TRAINING	REMEDIAL TRAINING	S_{12} L 1,2 - - - - - S_{13} L 4,3	S_{14} L 5,15,13	S_{11} F 4,2	S_8 F 11,13,5	S_{16} L 4,1	S_{12} L 14,8	PM
			S_{16} L 14,10,6	S_{15} L 6,10,14	S_{10} F 13,5,7	S_9 F 12,14,6	S_{14} L 7,11 - - - - - S_{15} L 8,12	S_{13} L 13,7	

	DAY 6		DAY 7		DAY 8		DAY 9		
AM	S_{10} F 3,2	S_8 F 7,15	S_{12} F 4,3 - - - - - S_{13} F 1,2	S_{14} F 8,6,14	S_8 L 2,4 - - - - - S_9 L 2,3		S_{16} F 2,3	S_{12} F 13,11	AM
	S_{11} F 10,12	S_9 F 8,10	S_{16} F 15,5,11	S_{15} F 7,5,11	S_{11} L 7,11,5	S_{10} L 10,14	S_{14} F12,10 - - - - - S_{15} F13,15	S_{13} F 14,12	
PM	FPTA/LTTA TRAINING		S_{11} L 1,3	S_8 L 14,8,12	S_{14} F 1,3 - - - - - S_{15} F 1,4	S_{12} F 15,7,5	S_{10} L 1,4	S_8 L 6,10	PM
			S_{10} L 8,12,6	S_9 L 13,7,11	S_{16} F 7,13	S_{13} F 10,8,6	S_{11} L 15,13	S_9 L 5,15	

Figure 11. Training and Testing Schedule for Keesler AFB Students, Class Size n = 9

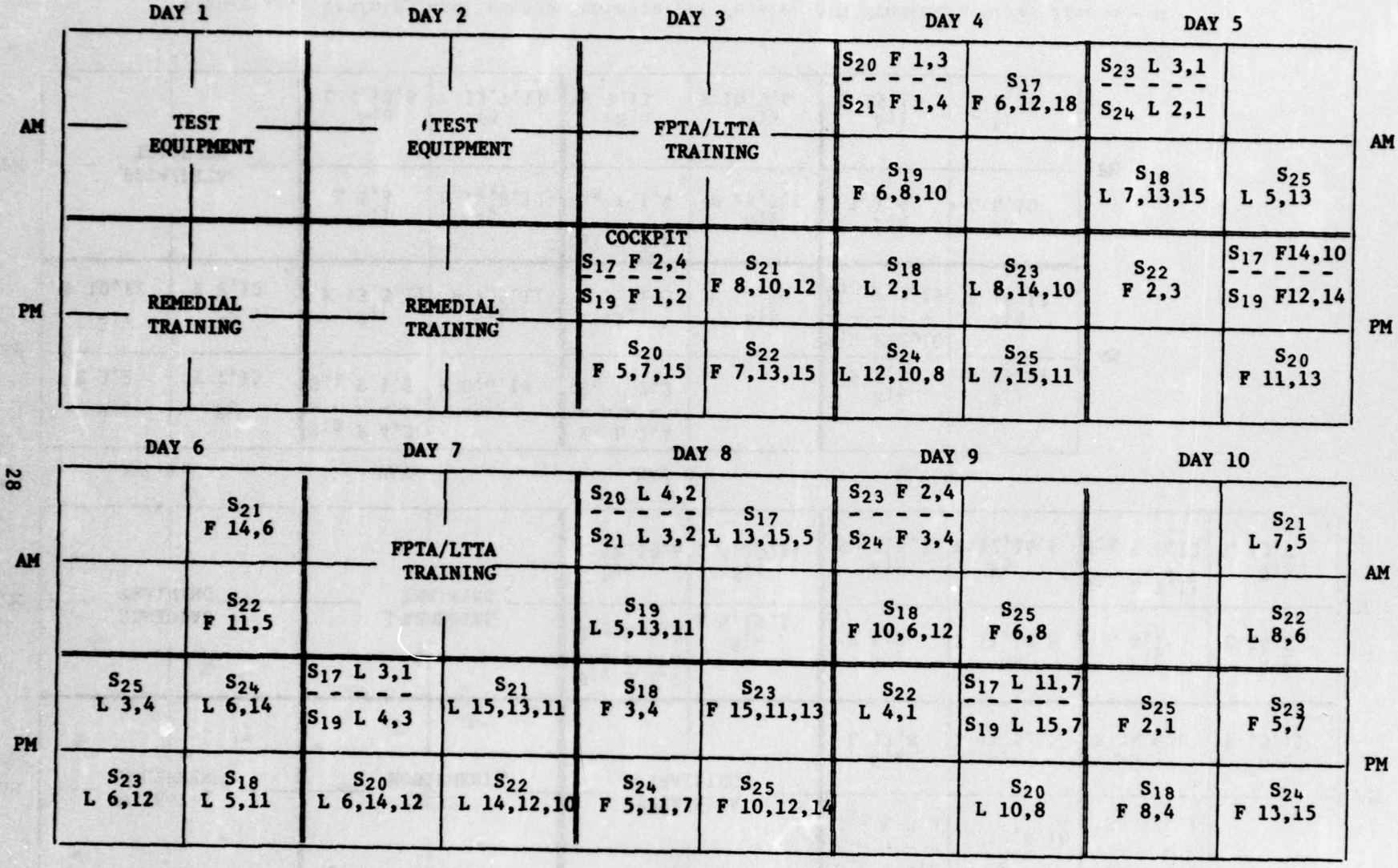


Figure 12. Training and Testing Schedule for Keesler AFB Students; Class Size n = 9, where S_{17} and S_{18} Complete Original Sequence, S_{19} Through 25 Start Repeat of Sequence

TABLE 1. EXAMPLE OF INDIVIDUAL TECHNICIAN SCHEDULE SHEET FOR KEESLER AFB TECHNICAL DATA EVALUATION

Date	Time	Location
Wed 8 October	AM	Classroom
	PM	Classroom
Thurs 9 October	AM	Classroom
	PM	Classroom
Fri 10 October	AM	Classroom
	PM	†
Tues 14 October	AM	†
	PM	Radar Bench/Trailer
Weds 15 October	AM	Radar Bench/Trailer
	PM	†
Thurs 16 October	AM	Cockpit/Trailer
	PM	Classroom
Fri 17 October	AM	Radar Bench/Trailer
	PM	†
Mon 20 October	AM	†
	PM	Cockpit/Trailer
Tues 21 October	AM	Radar Bench/Trailer
	PM	†

*AM = 0730 to 1130; PM = 1230 to 1630.
†As notified by experimental team.

TABLE 2. EXAMPLE OF SCHEDULING OF EXPERIMENTERS AND SUBJECTS FOR DAYS 3 THROUGH 9, 7 OCTOBER GRADUATING CLASS

COCKPIT

(Experimenter Name)

			Problems
Day 3 - 10 October			
(PM)	A1C (Subject name), S-5		L-3,1
Day 4 - 14 October			
(AM)	A1C ( ), S-6		L-2,1
(PM)	A1C ( ), S-4		F-2,3
Day 5 - 15 October			
(AM)	AMN ( ), S-3		F-1,4
(PM)	AMN ( ), S-7		L-3,4
Day 6 - 16 October			
(AM)	0730 - 0930 AMN ( ), S-1		F-1,2
	0931 - 1130 A1C ( ), S-2		F-1,3
(PM)	FPTA/LTTA Cross-Training		
Day 7 - 17 October			
(AM)	A1C ( ), S-4		L-4,1
(PM)	A1C ( ), S-5		F-2,4
Day 8 - 20 October			
(AM)	A1C ( ), S-6		F-3,4
(PM)	1230 - 1430 AMN ( ), S-1		L-4,3
	1431 - 1630 A1C ( ), S-2		L-4,2
Day 9 - 21 October			
(AM)	AMN ( ), S-3		L-3,2
(PM)	AMN ( ), S-7		F-2,1

Data Collection on Ancillary Factors

During the troubleshooting evaluation portion of the experiment, each subject was scheduled for troubleshooting for only one-half of each day (refer to Table 1). The half-day so committed was alternated (refer to Figures 10, 11, and 12) in an attempt to remove any order of time-of-day effect on a particular problem, technical data type, or subject.

The one-half day not involved with troubleshooting was used to collect ancillary data. Factors on which data were being collected included background, personality, attitude and aptitude. The instruments used in this process included the USAFI reading level test, No. 3; attitude and electronic background questionnaires developed for this experimental evaluation (Appendices A, B, C, and D); and a 376 item Adjustment Prediction Inventory developed by the author (Flyer and Potter, 1959). Imbedded in this inventory is the L.V. Gordon Profile (Gordon, 1953) and Personal Inventory (Gordon, 1956).

Earlier discussion indicated the decision to forego initial testing with the test equipment proficiency tests in the interest of time conservation. Since these instruments had no field validation, it was decided to administer, to the extent equipment availability permitted, these tests during the nontroubleshooting period of the day. Using this procedure, test performance data were collected on the proficiency tests covering the 410B VTVM (Item 1 in Figure 1), Simpson 260 VOM (Item 2), 545B Oscilloscope (Item 3), and TV Tube Tester (Item 5).

Procedure

First access to each graduating class was for a one-half hour period on the day of graduation. During this period, the members of the evaluation team were introduced; the purpose of the evaluation was described to the class; each class member was given his initial assignment for the following day; a tour of the trailer and classroom evaluation areas was conducted; and routine administrative announcements (e.g., messing, duty hours, and reporting chain of command for the two-week period) were made.

Day one and two of the class availability were devoted to test equipment (remedial) training following the schedules shown in Figure 2. The morning of day three was devoted to FPTA or LTTA training, depending on the group to which the airman was assigned. The afternoon of the third day was devoted either to troubleshooting of problems or to ancillary factor data collection. Again, the activity in which a class member was engaged depended upon the group to which he was assigned. Days four and five and the morning of day six were devoted to troubleshooting and ancillary data collection following schedules reflected in Table 1 and Figures 10, 11, and 12.

After he had completed all problems with the first type of data, each airman was asked to complete an opinion questionnaire on the data

format he had just used. After completing this form, he was entered (on the afternoon of day six) into cross-training on the use of the second experimental technical documentation format. Days seven, eight, and nine repeat the troubleshooting/ancillary data collection cycle described for days four, five and six.

The evaluation cycle for the class was completed at the close of day nine (day ten for the third graduating class) and the class was returned to regular duty (delay enroute to first operational assignment as an avionics inertial and radar navigation systems specialist).

At the completion of day nine troubleshooting problems, the airman completed an opinion questionnaire on the data format he had just used and then a second opinion questionnaire which asked him to compare the two formats. Copies of the questionnaires are given in Appendices D and E.

Testing Procedure

For each unique troubleshooting problem, the test administrator prepared the equipment by completing the "pretest setup" section of the problem contained in the Test Administrator's Guide (AFHRL-TR-76-74(III)). In addition, the presence of the support material requirements (listed in Section IV of each problem) was verified. At this point, the subject was brought into the troubleshooting situation. Following the instructions section (Section V) of the guide, the subject was given the information and instructions sheet (Appendix F) and asked to read it. He was then given the specific instructions sheet and the work order which described the problem he was to troubleshoot (Appendix G). (Refer to DD Form 1473, Block 18, AFHRL-TR-76-74(II).)

The troubleshooting evaluation was conducted on a one-on-one basis (one test administrator to one subject). The test administrator recorded data on student performance using such measures as time, errors, parts consumed, successful completion of each section, branching followed (and correctness) and success in troubleshooting. (See data recording forms included in Test Administrator's Guide.) The test administrator was instructed to answer no procedural questions while the test was ongoing. (The adequacy of the document to lead the student to the correct equipment malfunction was the basic item being evaluated.)

At no point in the troubleshooting process with either the Keesler or the Military Airlift Command subjects was the technician permitted to effect repairs of the equipment. In an operational situation, a troubleshooting philosophy adopted frequently includes removal and replacement of suspected parts and components, in effect, a trial and error approach to fault isolation. Following such an approach to troubleshooting with the experimental equipment (the cockpit, and AN/ASN-35 and AN/APN-147 bench mock-ups) would have exposed this equipment to an inordinate amount of abuse. The result could well have placed the evaluation in

jeopardy either through causing total equipment failure, or worse, by introducing insidious malfunctions which would permit the equipment to continue operating but which would produce fallacious equipment operating symptoms and signals. Thus, in the test situation when a technician indicated that he would remove and replace a specific component which was good, he was told to assume that he had done so and to continue as if he had replaced the part. Standard times were derived for removal and replacement of the components and parts identified by technicians in the evaluation and these times were added to subject time to obtain a total elapsed time to fault isolation.

MILITARY AIRLIFT COMMAND (MAC) OPERATIONAL SITES

The two remaining sample groups were obtained from Air Force enlisted personnel assigned in the 328X4 AFSC, who served as Avionics Inertial and Radar Navigational Systems Specialists, in operational units in MAC and performed maintenance on the AN/ASN-35 and AN/APN-147 systems of the C-141 aircraft.

Each of the two remaining sample groups had a size of n=18. The first of these groups was composed of airmen with AFSC 328X4 who had less than six months work experience on the systems; the second group, airmen in AFSC 328X4 with six months or more work experience on the systems.

Testing Locations and Subject Availability

The operational locations used for obtaining subjects were McChord, Travis, and McGuire Air Force Bases.

All MAC sites visited were operating on a three-shift day. Subjects from each of the three shifts were required to obtain the required sample sizes. Each individual was made available for a four-hour block of time each day that he participated in the evaluation. Each individual participated each day for four hours for a two-week period. Three shifts of Air Force maintenance personnel were covered with a two-shift operation on the part of the test administrators.

Test Equipment Testing and Remedial Training

The proficiency tests evaluating a technician's ability to use specific items of test equipment were administered on a selective basis. It was believed that a technician with field experience had a realistic assessment of his familiarity with a specific item of test equipment. For this reason, it was believed that presenting a technician with a list of test equipment (see Figure 5) and asking him to rank his ability to use each of the items would reveal those on which his proficiency would be verified. Except for items requiring that all subjects be

placed into training to ensure greater familiarity, proficiency tests were administered only when the subject technician indicated a questionable proficiency.

Equipment Faults

The MAC subjects were exposed to the full set of 15 equipment faults (see Figure 7). Four of the faults were representative of organizational level maintenance troubleshooting tasks on the AN/ASN-35 and AN/APN-147 equipment. The remaining 11 faults were representative of intermediate level maintenance troubleshooting tasks.

At the organizational level of maintenance, an equal number of computer (ASN-35) and radar (APN-147) faults were included. Thus, the four organizational level faults consisted of two computer malfunctions and two radar malfunctions. The 11 intermediate level faults included five computer and six radar malfunctions.

An attempt was made with the organizational and intermediate level faults to categorize them on an additional dimension: levels of troubleshooting. Three levels of troubleshooting were used for this purpose: *troubleshoot to unit*, *troubleshoot to subassembly*, and *troubleshoot to part*.

Both the organizational and intermediate level faults were counterbalanced in presentation order to subjects, and each fault was isolated an equal number of times with TO, LTTA, and FPTA documentation.

Order of Technical Data Training

Reference is made to the order of counterbalancing scheme diagrammed in Figure 13. In this portion of the evaluation, subjects were exposed to all three formats of technical data: TOs, FPTAs, and LTTAs. The order in which the documentation types were assigned to problems was determined by random selection. Thus, sequence (TO, FPTA, LTTA) was assigned for the first three problems subject one encountered, in both organizational and intermediate troubleshooting. This sequence was then repeated to fill the 4 × 18 matrix of cells for the organizational level problem presentation and the 11 × 18 matrix for the intermediate problem presentation. Thus, presentation order was systematically counterbalanced with problems and each data type was used an equal number of times with each problem.

Each subject with six months or less experience on the system was paired with a number from 1 to 18 using a random assignment process. This assignment process determined the particular sequence in which the problems were presented to the subject. Further, the 18 subjects were separated into three equal size groups (subjects 1 through 6 [Figure 14], subjects 7 through 12 [Figure 15], subjects 13 through 18 [Figure 16]). The first of these groups was assigned a sequence of document

	ORGANIZATIONAL				INTERMEDIATE													
Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	L	T	F
1	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
2	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
3	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
4	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
5	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
6	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
7	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
8	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
9	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
10	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
11	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
12	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
13	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
14	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
15	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
16	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
17	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
18	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
No. Times Data Named Is Used																		
LTTA	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			
FPTA	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			
TO	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			

Figure 13. Order of Counterbalancing of Problems and Data Format Subjects for Military Airlift Command Where Subjects Fall in the Group of 5-Level Technicians with 6 Months or Less Experience in the AFSC

Subject	FPTA		LTTA		TO	
	Org	Intermed	Org	Intermed	Org	Intermed
1	I 2	5,8,11,14	O 3	6,9,12,15	I 1,4	7,10,13
2	O 4,1	10,13,7	I 2	8,11,14,15	O 3	9,12,15,6
3	I 3	12,15,6,9	O 1,4	13,7,10	I 2	11,14,8,5
4	O 2	14,5,8,11	I 3	15,6,9,12	O 4,1	7,10,13
5	I 3	6,9,12,15	O 1,4	10,13,7	I 2	5,8,11,14
6	O 3	9,12,15,6	I 4,1	7,10,13	O 2	8,11,14,5

FPTA
FIRST

Figure 14. Presentation Sequence for Problems by Subjects by Type of Technical Documentation for Military Airlift Command Subjects Where Subjects are 5-Level with 6 Months or Less Experience at That Level

Subject	LTTA		TO		FPTA	
	Org	Intermed	Org	Intermed	Org	Intermed
7	I 3	6,9,12,15	O 1,4	7,10,13	I 2	5,8,11,14
8	O 2	8,11,14,5	I 3	9,12,15,6	O 4,1	10,13,7
9	I 1,4	13,7,10	O 2	11,14,5,8	I 3	12,15,6,9
10	O 3	15,6,9,12	I 4,1	7,10,13	O 2	14,5,8,11
11	I 2	5,8,11,14	O 3	6,9,12,15	I 1,4	10,13,7
12	O 4,1	13,7,10	I 2	8,11,14,5	O 3	9,12,15,6

LTTA
FIRST

Figure 15. Presentation Sequence for Problems by Subjects by Type of Technical Documentation for Military Airlift Command Subjects Where Subjects are 5-Level with 6 Months or Less Experience at That Level

Subject	TO		FPTA		LTTA	
	Org	Intermed	Org	Intermed	Org	Intermed
13	I 1,4	7,10,13	O 2	5,8,11,14	I 3	6,9,12,15
14	O 3	9,12,15,6	I 4,1	10,13,7	O 2	8,11,14,5
15	I 3	12,15,6,9	O 1,4	13,7,10	I 2	11,14,5,8
16	O 4,1	7,10,13	I 2	14,5,8,11	O 3	15,6,9,12
17	I 3	6,9,12,15	O 1,4	10,13,7	I 2	5,8,11,14
18	O 2	8,11,14,5	I 3	9,12,15,6	O 4,1	13,7,10

TO
FIRST

Figure 16. Presentation Sequence for Problems by Subjects by Type of Technical Documentation for Military Airlift Command Subjects Where Subjects are 5-Level with 6 Months or Less Experience at That Level

type. The subjects in Group 1 (Figure 14) solved problems first with FPTA documentation; second with LTTA; and last, with TO. Order of presentation was counterbalanced for the other two groups with the following results: Group--2 LTTA, TO, FPTA; Group 3--TO, FPTA, LTTA. The sequence of problems and orders of data format presentation which resulted for the subjects having six months or less experience as 5-level technicians are presented in Figures 13, 14, 15, and 16.

Comparable schedules for the sample group (size n=18) composed of 5-level technicians with more than six months experience are presented in Figures 17, 18, 19, and 20.

To assemble the sequences and orders depicted in Figures 17, 18, 19, and 20 a new group of 18 numbers (19 through 36) was randomly assigned to the problem sequences appearing in Figure 13, resulting in the schedule appearing as Figure 17. The content of Figures 18, 19, and 20 was generated from the data in Figure 17 following the procedure described previously.

Subjects

The characteristics of the subject groups obtained from MAC operational sites have been discussed in earlier sections. An example of the schedules used at each of the MAC sites is presented in Figures 21 through 23.

Data Collection on Ancillary Factors

With the MAC sample groups, with the exception of the United States Air Force Institute (USAFI) reading score, identical ancillary data to that collected with the Keesler subjects were obtained. Ancillary data were obtained at any time the subject was available and was not required for primary data collection activities.

Procedure

The procedure followed at each MAC base was dependent upon the agreements reached with base personnel. As the base requirements were revealed, a procedure was established so that a standard approach to each subject on that base was maintained. To the extent possible, the procedure at each MAC base was the same and conformed as nearly to the Keesler subject procedure as was practical.

Variations in procedures from base to base were primarily administrative with respect to access to technicians and physical facilities. In all cases, once the subject was placed in the troubleshooting problem, he was treated in an identical manner to Keesler subjects and the same measures were obtained on the subject.

	ORGANIZATIONAL				INTERMEDIATE													
Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	L	T	F
19	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
20	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
21	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
22	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
23	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
24	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
25	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
26	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
27	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
28	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
29	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
30	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
31	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
32	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
33	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	5	5	5
34	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	5	5	5
35	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
36	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	5	5	5
No. Times Data Named Is Used																		
LTTA	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			
FPTA	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			
TO	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			

Figure 17. Order of Counterbalancing of Problems and Data Format by Subjects for Military Airlift Command Where Subjects Fall in the Group of 5-Level Technicians with More Than 6 Months Experience in the AFSC

Subject	FPTA		LTTA		TO	
	Org	Intermed	Org	Intermed	Org	Intermed
19	I 1,4	7,10,13	O 2	5,8,11,14	I 3	6,9,12,15
20	O 3	9,12,15,6	I 4,1	10,13,7	O 2	8,11,14,5
21	I 2	11,14,5,8	O 3	12,15,6,9	I 1,4	13,7,10
22	O 2	14,5,8,11	I 3	15,6,9,12	O 4,1	7,10,13
23	I 2	5,8,11,14	O 3	6,9,12,15	I 1,4	10,13,7
24	O 3	9,12,15,6	I 4,1	13,7,10	O 2	8,11,14,5

FPTA
FIRST

Figure 18. Presentation Sequence for Problems by Subjects by Type of Technical Documentation for Military Airlift Command Subjects Where Subjects are 5-Level with More than 6 Months Experience at That Level

Subject	LTTA		TO		FPTA	
	Org	Intermed	Org	Intermed	Org	Intermed
25	I 2	5,8,11,14	O 3	6,9,12,15	I 1,4	7,10,13
26	O 2	8,11,14,5	I 3	9,12,15,6	O 4,1	10,13,7
27	I 1,4	13,7,10	O 2	11,14,5,8	I 3	12,15,6,9
28	O 3	15,6,9,12	I 4,1	7,10,13	O 2	14,5,8,11
29	I 1,4	10,13,7	O 2	5,8,11,14	I 3	6,9,12,15
30	O 4,1	7,10,13	I 2	8,11,14,5	O 3	9,12,15,6

LTTA
First

Figure 19. Presentation Sequence for Problems by Subjects by Type of Technical Documentation for Military Airlift Command Subjects Where Subjects are 5-Level with More than 6 Months Experience at That Level

Subject	TO		FPTA		LTTA	
	Org	Intermed	Org	Intermed	Org	Intermed
31	I 3	6,9,12,15	O 1,4	7,10,13	I 2	5,8,11,14
32	O 4,1	10,13,7	I 2	8,11,14,5	O 3	9,12,15,6
33	I 1,4	13,7,10	O 2	11,14,5,8	I 3	12,15,6,9
34	O 2	14,5,8,11	I 3	15,6,9,12	O 4,1	7,10,13
35	I 3	6,9,12,15	O 1,4	10,13,7	I 2	5,8,11,14
36	O 3	12,15,6,9	I 1,4	7,10,13	O 2	8,11,14,5

TO
FIRST

Figure 20. Presentation Sequence for Problems by Subjects by Type of Technical Documentation for Military Airlift Command Subjects Where Subjects are 5-Level with More than 6 Months Experience at That Level

TRAVIS AFB

First Two Weeks

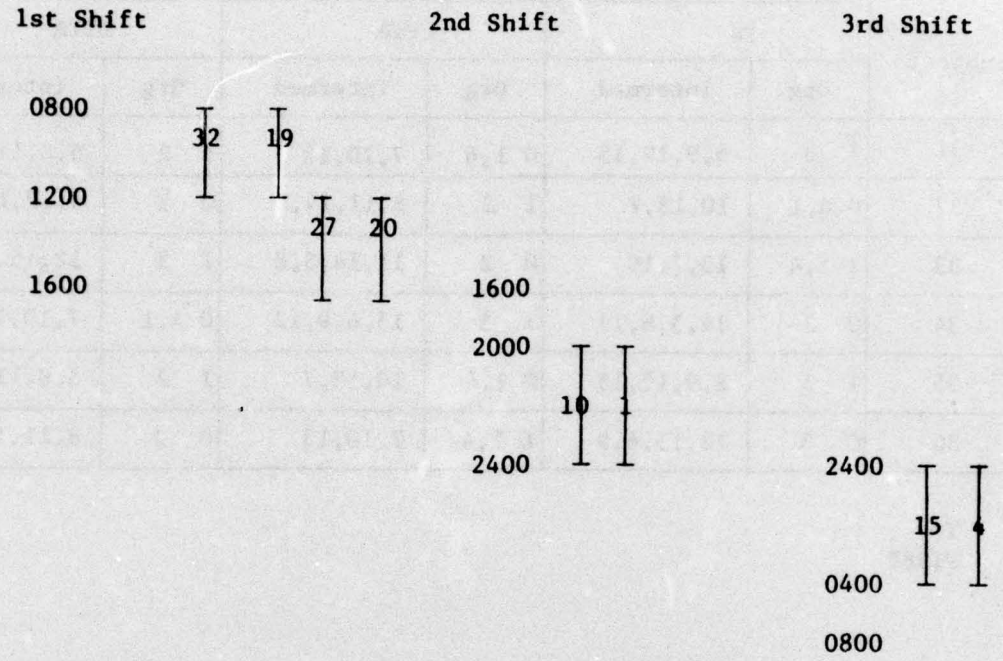


Figure 21. Schedule of Travis AFB Subjects, by Subject Number and Time Available, for the First Two Weeks of Evaluation

TRAVIS AFB

Second Two Weeks

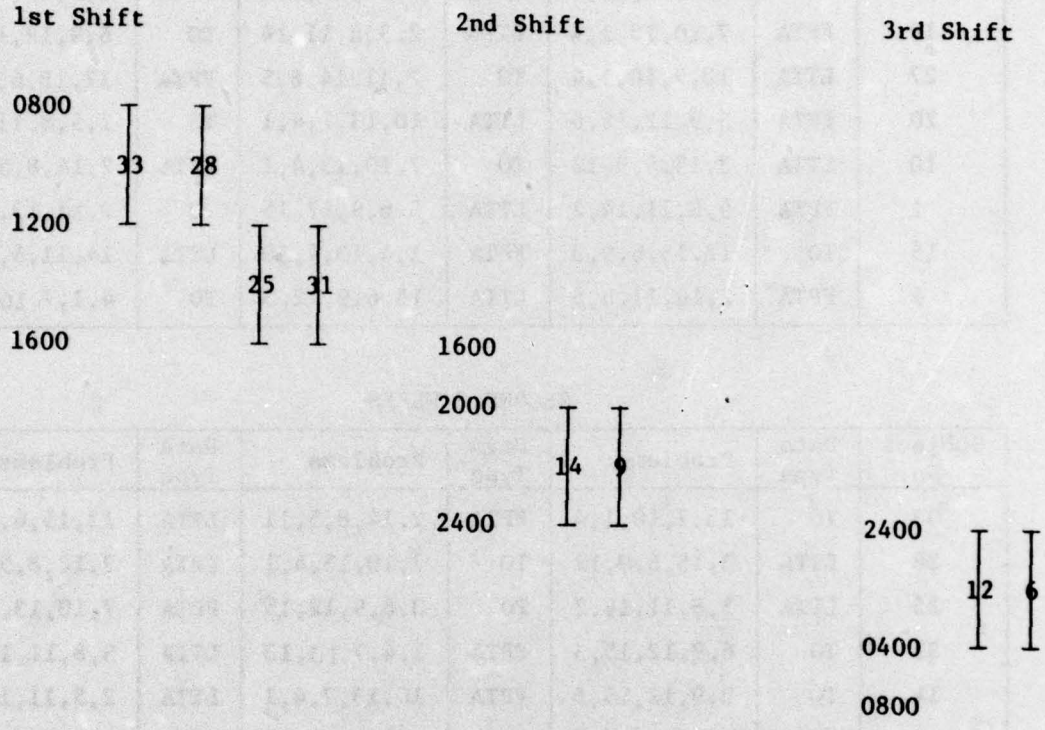


Figure 22. Schedule of Travis AFB Subjects, by Subject Number and Time Available, for the Second Two Weeks of Evaluation

FIRST 2 WEEKS

Subject No.	Data Type	Problems	Data Type	Problems	Data Type	Problems
32	TO	4,1,10,13,7	FPTA	8,14,11,5,2	LTTA	3,9,12,15,6
19	FPTA	7,10,13,1,4	LTTA	2,5,8,11,14	TO	6,9,12,15,3
27	LTTA	13,7,10,1,4	TO	2,11,14,8,5	FPTA	12,15,6,9,3
20	FPTA	3,9,12,15,6	LTTA	10,13,7,4,1	TO	2,5,8,11,14
10	LTTA	3,15,6,9,12	TO	7,10,13,4,1	FPTA	2,14,8,5,11
1	FPTA	5,8,11,14,2	LTTA	3,6,9,12,15	TO	7,10,13,1,4
15	TO	12,15,6,9,3	FPTA	1,4,13,7,10	LTTA	14,11,5,8,2
4	FPTA	2,14,11,8,5	LTTA	15,6,9,12,3	TO	4,1,7,10,13

SECOND 2 WEEKS

Subject No.	Data Type	Problems	Data Type	Problems	Data Type	Problems
33	TO	13,7,10,1,4	FPTA	2,14,8,5,11	LTTA	12,15,6,9,3
28	LTTA	3,15,6,9,12	TO	7,10,13,4,1	FPTA	2,14,8,5,11
25	LTTA	5,8,11,14,2	TO	3,6,9,12,15	FPTA	7,10,13,1,4
31	TO	6,9,12,15,3	FPTA	1,4,7,10,13	LTTA	5,8,11,14,2
14	TO	3,9,12,15,6	FPTA	10,13,7,4,1	LTTA	2,5,11,14,8
9	LTTA	13,7,10,1,4	TO	2,5,8,11,14	FPTA	12,15,6,9,3
12	LTTA	4,1,13,7,10	TO	14,11,8,5,2	FPTA	3,9,12,15,6
6	FPTA	3,9,12,15,6	LTTA	7,10,13,4,1	TO	2,8,14,11,5

Figure 23. Problem Sequence by Documentation and Subject Number for Travis AFB Subjects

REFERENCES

Flyer, E. S. and Potter, N. R. Characteristics of basic airmen willing to volunteer for a six-year tour in missile squadrons. WADC-TN-59-35, AD-210 476. Lackland AFB, TX: Personnel Laboratory, Wright Air Development Center, February 1959.

Gordon, L. V. Gordon personal profile and personal inventory. New York: World Book Co., 1953.

Gordon, L. V. Gordon personal inventory. New York: World Book Co., 1956.

Potter, N. R. Evaluation of three types of technical data for troubleshooting: Test administor's guide. AFHRL-TR-76-74(III). AD-A031 850. Wright-Patterson AFB, OH: Advanced Systems Division, Air Force Human Resources Laboratory, September 1976.

APPENDIX A

KEESLER AFB PRE-EXPERIMENT
BIOGRAPHICAL INFORMATION

NAME: _____

RANK: _____

AFSC: _____

1. Date entered course 3ABR32834: _____

2. AFSC's other than 32834 held: _____

3. List any other course work in electronics or engineering:

Course	Where Taken	Credit Hours Earned or Weeks in Training
_____	_____	_____
_____	_____	_____
_____	_____	_____

4. List any previous electronics or engineering job experience:

Job Title	Organization	Length of Time
_____	_____	_____
_____	_____	_____
_____	_____	_____

5. Have any of your hobbies been electronics or engineering oriented?

Yes _____ No _____

If yes, list those hobbies.

_____

_____

6. Have you ever used TOs for maintenance troubleshooting?

Yes _____ No _____

If yes, check the number of times.

1-5 _____
6-10 _____
over 10 _____

7. Check the highest grade (or level) of education.

High School nongraduate	_____
High School graduate	_____
1 year of college	_____
2 years of college	_____
3 years of college	_____
4 years of college, but no degree	_____
Bachelor's Degree	_____

If one or more years of college, list major.

_____

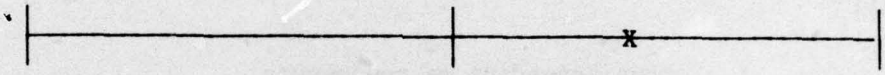
APPENDIX B

FPTA

MID-EXPERIMENT QUESTIONNAIRE

NAME: _____

NOTE: For questions 1 and 2, place an "X" along the scale at the point that represents your opinion about the item being discussed. As an example, if the question were: How do you feel about vanilla ice cream?



Don't like it, never eat it

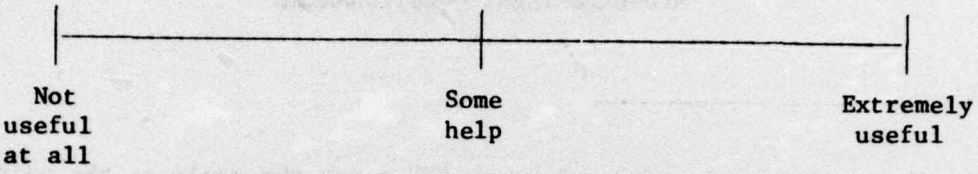
Like it as well as any other flavor

Won't eat anything else

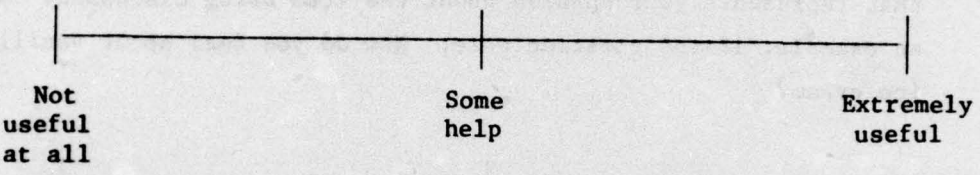
The position of the "X" would indicate that the individual answering the question preferred vanilla but would eat other flavors.

1. How do you feel about the FPTA as an aid in troubleshooting the maintenance problems you have just had at the following levels of maintenance?

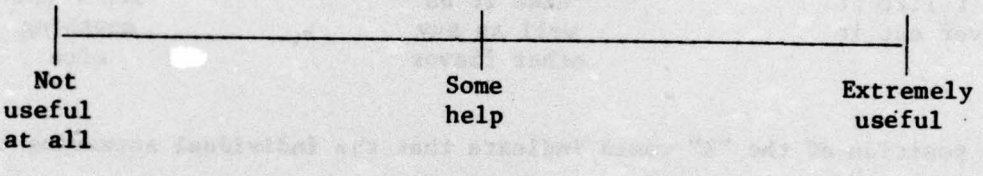
COCKPIT LEVEL



BENCH LEVEL TO SUBASSEMBLIES

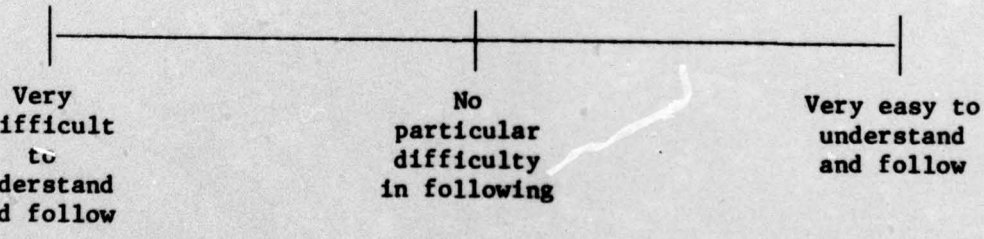


SUBASSEMBLIES TO COMPONENTS



Comments:

2. How easy was it to understand the FPTA?



3. What do you feel are problems with the FPTA?

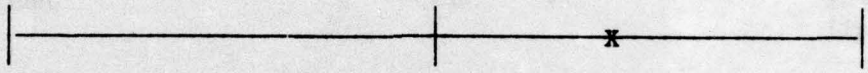
APPENDIX C

LTTA

MID-EXPERIMENT QUESTIONNAIRE

NAME: _____

NOTE: For questions 1 and 2, place an "X" along the scale at the point that represents your opinion about the item being discussed. As an example, if the question were: How do you feel about vanilla ice cream?



Don't like it, never eat it	Like it as well as any other flavor	Won't eat anything else

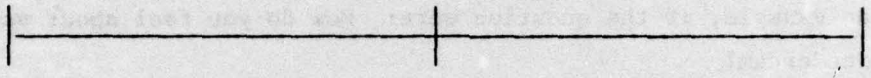
The position of the "X" would indicate that the individual answering the question preferred vanilla but would eat other flavors.

1. How do you feel about the LTTA as an aid in troubleshooting the maintenance problems you have just had at the following levels of maintenance?

COCKPIT LEVEL

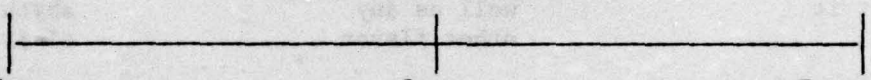
Not useful at all	Some help	Extremely useful

BENCH LEVEL TO SUBASSEMBLIES



Not useful at all	Some help	Extremely useful

SUBASSEMBLIES TO COMPONENTS



Not useful at all	Some help	Extremely useful

Comments:

2. How easy was it to understand the LTTA?

Very difficult to understand and follow	No particular difficulty in following	Very easy to understand and follow

3. What do you feel are problems with the LTTA?

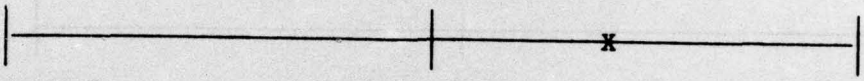
APPENDIX D

TO

MID-EXPERIMENT QUESTIONNAIRE

NAME: _____

NOTE: For questions 1 and 2, place an "X" along the scale at the point that represents your opinion about the item being discussed. As an example, if the question were: How do you feel about vanilla ice cream?

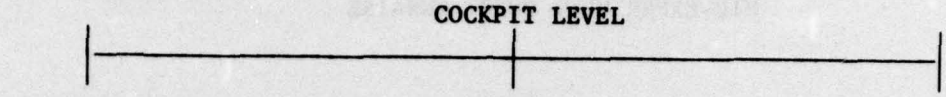


Don't like it, never eat it	Like it as well as any other flavor	Won't eat anything else

The position of the "X" would indicate that the individual answering the question preferred vanilla but would eat other flavors.

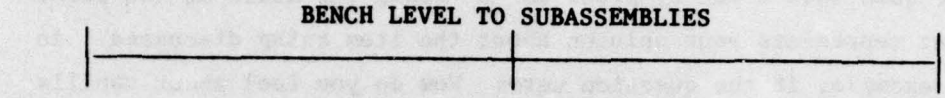
1. How do you feel about the TOs as an aid in troubleshooting the maintenance problems you have just had at the following levels of maintenance?

COCKPIT LEVEL



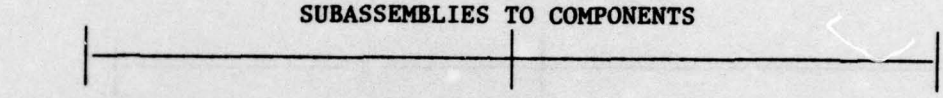
Not useful at all — Some help — Extremely useful

BENCH LEVEL TO SUBASSEMBLIES



Not useful at all — Some help — Extremely useful

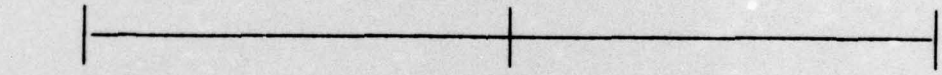
SUBASSEMBLIES TO COMPONENTS



Not useful at all — Some help — Extremely useful

COMMENTS:

2. How easy was it to understand the TOs?



Very difficult to understand and follow — No particular difficulty in following — Very easy to understand and follow

3. What do you feel are problems with the TO?

APPENDIX E-1

POST-EXPERIMENT QUESTIONNAIRE

(Keesler)

NAME: _____

NOTE: For questions 1 through 4, place an "X" along the scale at the point that represents your opinion about the item being discussed. As an example, if the question were: How do you feel about vanilla ice cream?

Don't like it, never eat it

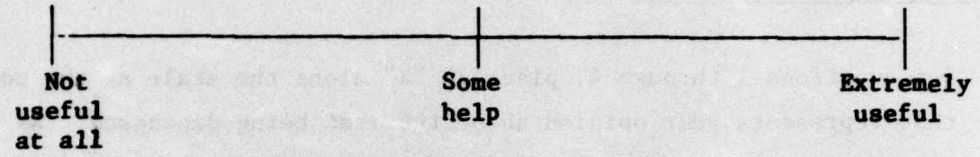
Like it as well as any other flavor

Won't eat anything else

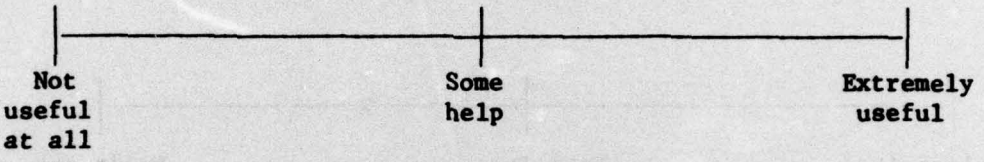
The position of the "X" would indicate that the individual answering the question preferred vanilla but would eat other flavors.

1. How do you feel about the FPTA as an aid in troubleshooting the maintenance problems you have just had at the following levels of maintenance?

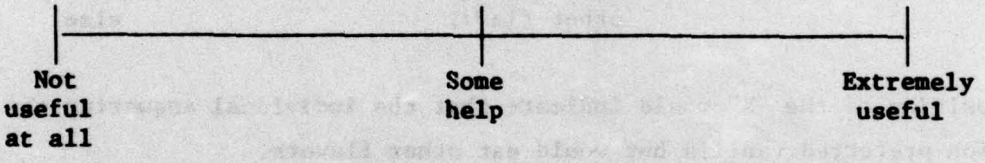
COCKPIT LEVEL



BENCH LEVEL TO SUBASSEMBLIES



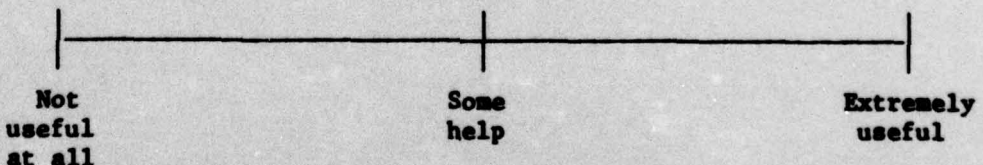
SUBASSEMBLIES TO COMPONENTS



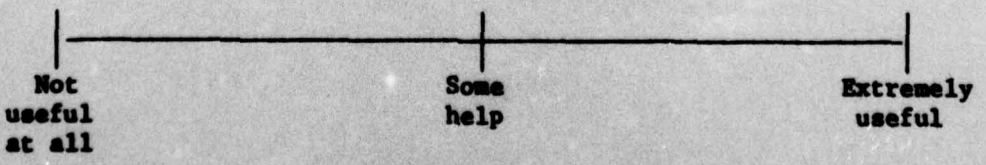
Comments:

2. How do you feel about the LTTA as an aid in troubleshooting the maintenance problems you have just had at the following levels of maintenance?

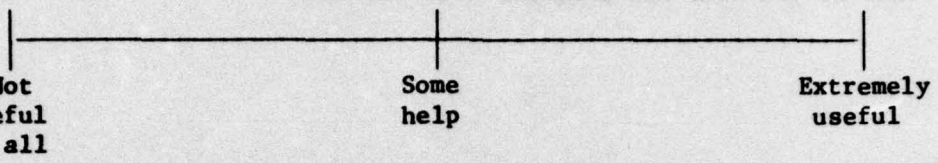
COCKPIT LEVEL



BENCH LEVEL TO SUBASSEMBLIES

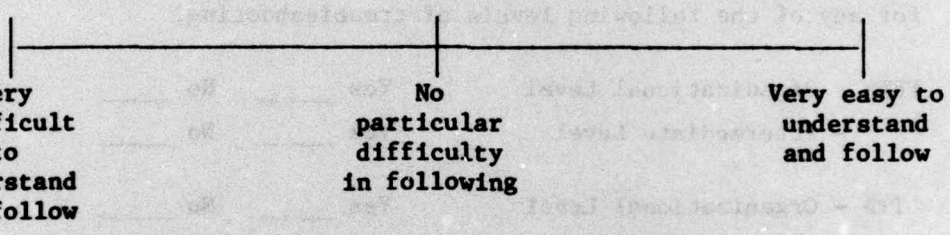


SUBASSEMBLIES TO COMPONENTS

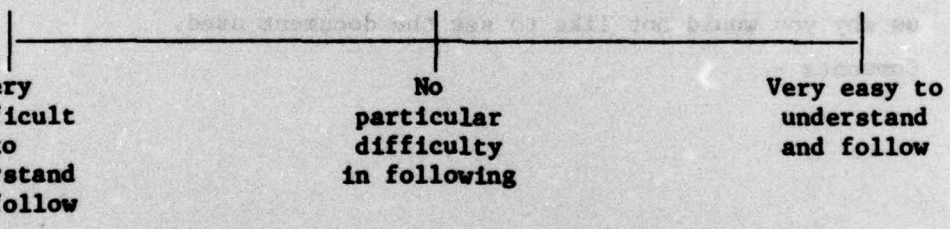


Comments:

3. How easy was it to understand the FPTA?



4. How easy was it to understand the LTTA?



5. What do you feel are problems with the FPTA?

6. What do you feel are problems with the LTTA?

7. Which troubleshooting method was the easiest to follow? _____
Why?

8. Would you like to see the Air Force use FPTA or LTTA documentation for any of the following levels of troubleshooting?

FPTA - Organizational Level	Yes _____	No _____
- Intermediate Level	Yes _____	No _____
LTTA - Organizational Level	Yes _____	No _____
- Intermediate Level	Yes _____	No _____

9. If you answered "NO" to any part of question 8 above, please tell us why you would not like to see the document used.
Comments -

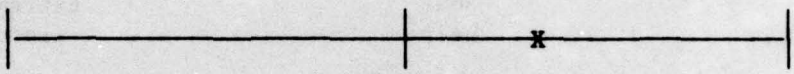
APPENDIX E-2

POST-EXPERIMENT QUESTIONNAIRE

(Military Air lift Command)

NAME: _____

NOTE: For questions 1 through 4, place an "X" along the scale at the point that represents your opinion about the item being discussed. As an example, if the question were: How do you feel about vanilla ice cream?



Don't like it, Never eat it

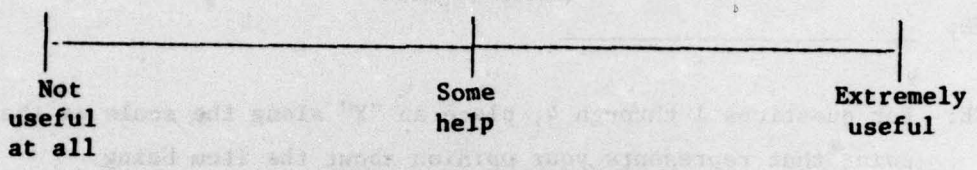
Like it as well as any other flavor

Won't eat anything else

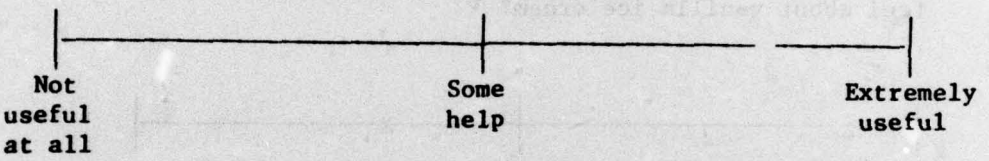
The position of the "X" would indicate that the individual answering the question preferred vanilla but would eat other flavors.

1. How do you feel about the FPTA as an aid in troubleshooting the maintenance problems you have just had at the following levels of maintenance?

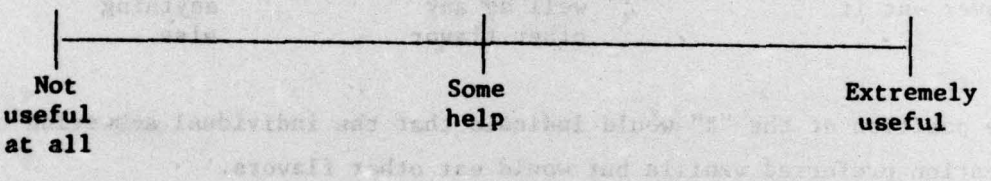
COCKPIT LEVEL



BENCH LEVEL TO SUBASSEMBLIES



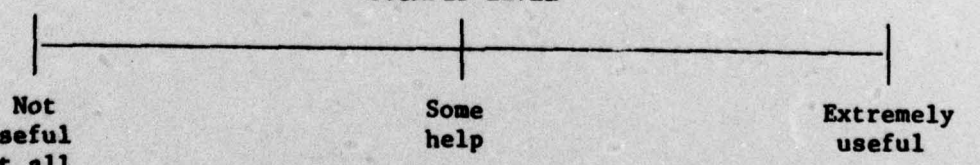
SUBASSEMBLIES TO COMPONENTS



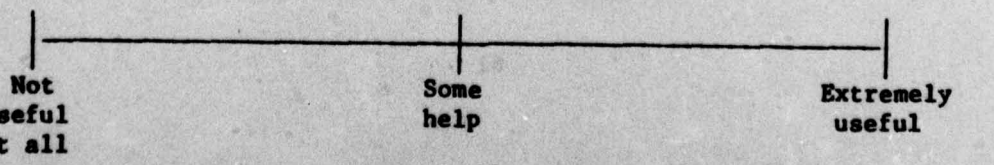
Comments:

2. How do you feel about the LTTA as an aid in troubleshooting the maintenance problems you have just had at the following levels of maintenance?

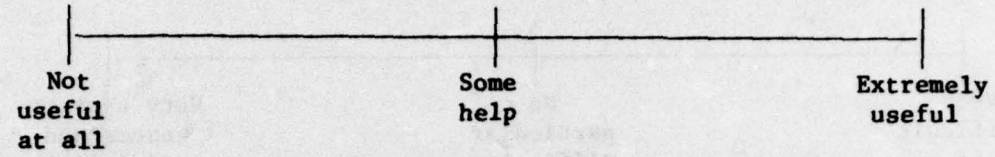
COCKPIT LEVEL



BENCH LEVEL TO SUBASSEMBLIES



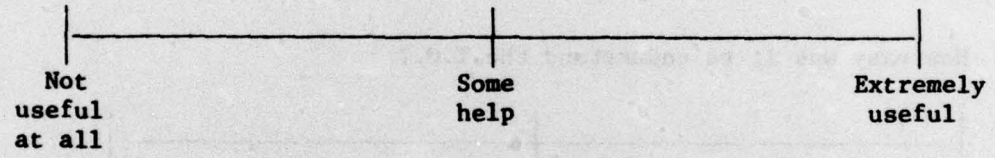
SUBASSEMBLIES TO COMPONENTS



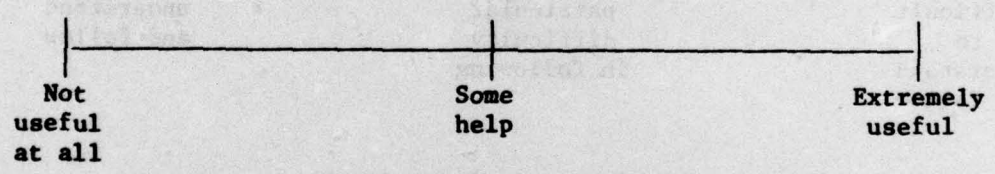
Comments:

3. How do you feel about the T.O. as an aid in troubleshooting the maintenance problems you have just had at the following levels of maintenance?

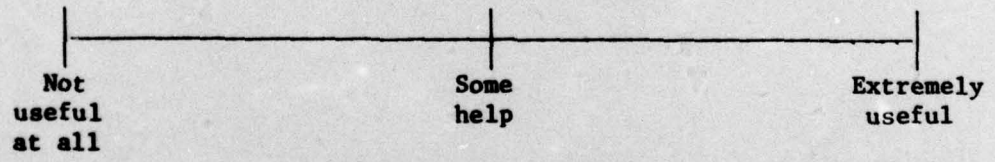
COCKPIT LEVEL



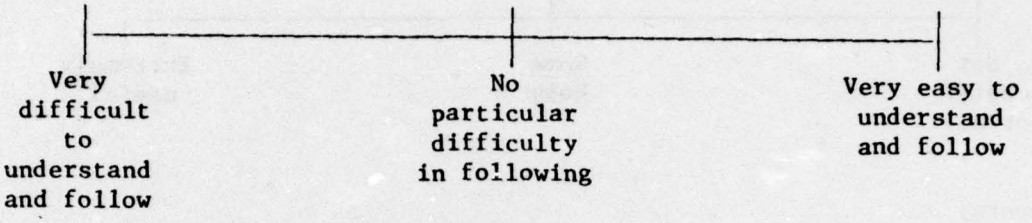
BENCH LEVEL TO SUBASSEMBLIES



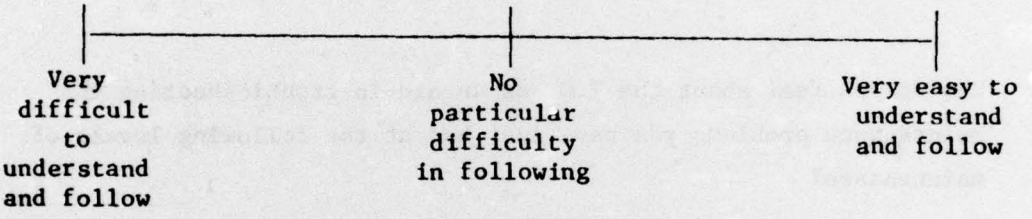
SUBASSEMBLIES TO COMPONENTS



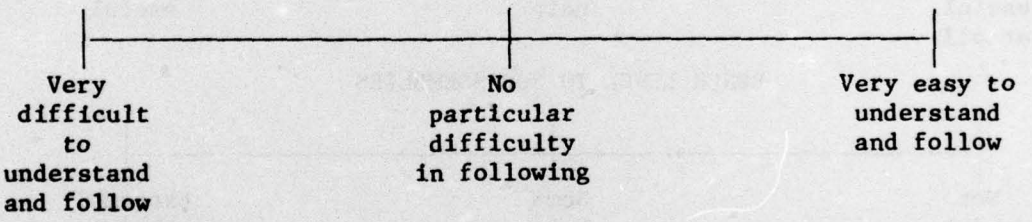
4. How easy was it to understand the FPTA?



5. How easy was it to understand the LTTA?



6. How easy was it to understand the T.O.?



7. What do you feel are problems with the FPTA?

8. What do you feel are problems with the LTTA?

9. What do you feel are problems with the TO?

10. Which troubleshooting method was the easiest to follow? _____
Why?

11. Would you like to see the Air Force use FPTA or LTTA documentation for any of the following levels of troubleshooting?

FPTA - Organizational Level	Yes _____	No _____
- Intermediate Level	Yes _____	No _____
LTTA - Organizational Level	Yes _____	No _____
- Intermediate Level	Yes _____	No _____

12. If you answered "NO" to any part of question 11 above, please tell us why you would not like to see the document used.
Comments:

APPENDIX F

INFORMATION AND INSTRUCTIONS

Evaluation of Different Types of Technical Data for Troubleshooting

You have been asked by the Air Force to help them in providing answers to a number of very important questions about the suitability of two new types of technical data for equipment maintenance and troubleshooting.

The Air Force is interested in providing manuals which assist the technician in his desire to do the best possible job of equipment maintenance. However, without your help, the Air Force will not have the information it needs to make a correct decision about the merits of each of the proposed documents. For this reason, you are being asked to use each of the documents in troubleshooting a series of carefully selected equipment problems.

You are being asked to work on these problems in a closely controlled experimental evaluation. In brief, the Air Force is asking you to be an experimental subject in its field evaluation of the technical data. For this reason, it is important that you follow all instructions given you.

One way of comparing the merits of different types of technical manuals is to find out how long it takes to correctly isolate an equipment problem using a particular document.

Attempts have been made to select problems which can be located within an hour of troubleshooting. To find out if our estimates are correct, time required to solve each problem will be recorded. We would like to emphasize that we are NOT interested in finding out how quickly YOU can solve the problem; we want to know the length of time it takes the proposed technical document to guide you to the correct solution. YOU ARE NOT BEING TESTED -- THE DOCUMENT IS!

APPENDIX G

EXAMPLE

SPECIFIC INSTRUCTIONS

1. Approximately one hour is allocated to each troubleshooting problem. There is more than enough time for each problem, so do not rush.
2. The technical document you are using is intended to be self-explanatory. If you have a problem, read the item in question again. If after repeating the item you still have a problem, then ask the experimenter.
3. Notify the experimenter of any decisive steps (removal of parts or branching from steps) BEFORE making them.
4. Tools not furnished will be supplied upon request if required.
5. When time is started, you are to turn this page, read the work order given, and begin the troubleshooting procedures.
6. Manuals for the test equipment are available for you to use if necessary.
7. During this exercise, observe all of the standard safety procedures.
8. The experimenter will inform you when the time is up.

DO NOT TURN THIS PAGE UNTIL INSTRUCTED TO DO SO BY THE EXPERIMENTER.

WORK ORDER

Troubleshoot malfunctioning Radar Receiver-Transmitter down to faulty subassembly.

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